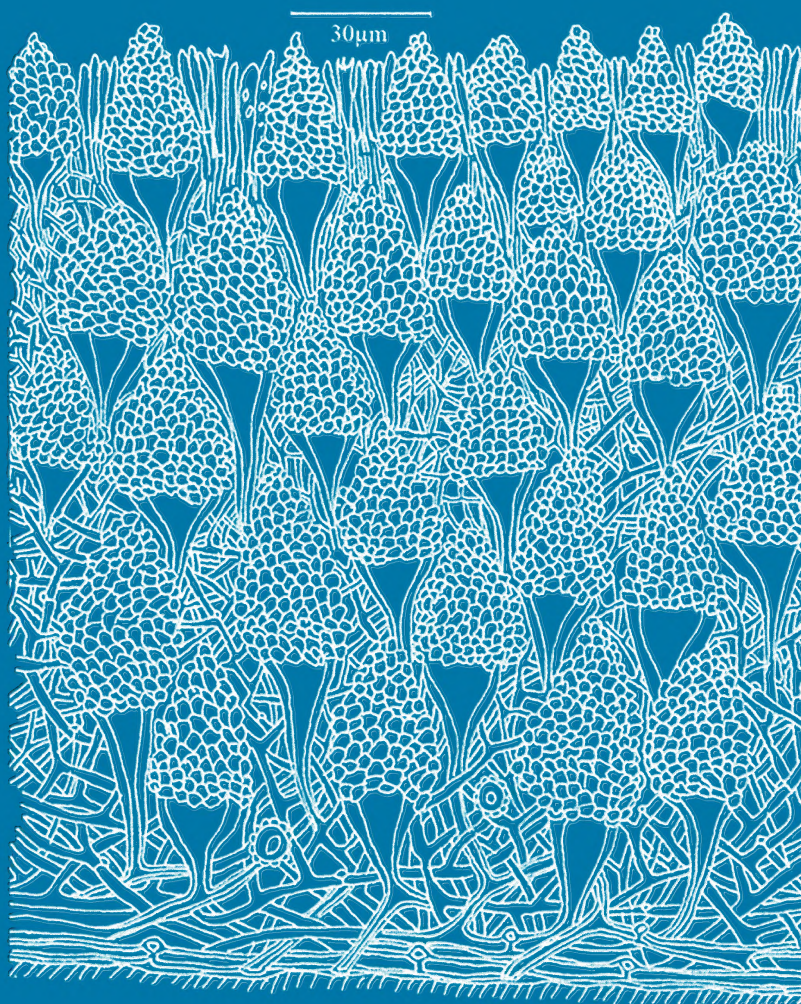


MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

VOLUME 126

OCTOBER–DECEMBER 2013



Peniophora hallenbergii sp. nov.
(Samita & Dhingra— Pl. 1.7, p. 236)

SAMITA, artist

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FROM THE EDITOR-IN-CHIEF

MYCOTAXON 126, which owes its slimness to a temporary presubmission review bottleneck, presents 27 excellent papers by 87 authors from 21 countries and revised by 50 expert reviewers. Within its pages are two new genera (*Ambomucor* and *Embryonispora* from China) plus 22 other taxa new to science representing *Ambomucor*, *Bahusutrabeeja*, *Craterium*, *Embryonispora*, *Hypoxylon*, *Linodochium*, *Lophodermium*, *Passolora*, *Phyllobaeis*, *Spadicoides*, *Terriera*, and *Tuber* from China; *Annulohypoxylon* and *Nectria* from Russia; *Flavophlebia* and *Peniophora* from India; *Nipponoparmelia* from Russia and South Korea, and from the United States a new *Phytophthora* from irrigation water in Virginia and a new underwater (!) *Peziza* from Oregon.

In addition to range extensions and new hosts for previously named taxa, we also offer one new *Entocybe* combination from Australia, 46 new (and eagerly awaited) combinations in *Trichoderma*, a reevaluation of *Neopaxillus*, and two excellent taxonomic revisions—one on Zdeněk Schaefer's *Lactarius* taxa in Prague, the other a comprehensive treatment of *Pluteus* collections previously studied by Hennings and Rick in Brazil. We close with some excellent book reviews!

MYCOTAXON POLICY ON AUTHORSHIP ORDER —During 2013, your editors encountered several perplexing authorship changes during our review process. Puzzled by an apparent upsurge in authorship-shifting, we eventually learned that some labs conduct questionable 'bidding wars' where authors pay for first authorship, a scourge particularly common in manuscripts submitted to international journals. While we do not like to think ill of our contributors, there seems little other logical explanation for changing first authorship status on a paper reviewed with one set of authors, accessioned with another, and then with a first author demoted or disappearing by request of the submitting author just prior to publication. This makes little scientific sense: almost always the first author 'drives' a manuscript from inception through publication, with the 'submitting' author serving a secondary but necessary role when there are language or technical difficulties.

MYCOTAXON no longer permits a change of first authorship status after an accession number has been assigned; we expect first authors to remain in that position after submission to the Nomenclature Editor. A coauthor may be added or the co-author order may change only when we and the expert reviewers approve the change.

PLUS ÇA CHANGE, PLUS C'EST MÊME CHOSE —Tired of scrolling up to the next column in the middle of a multi-column page? Frustrated with squinting at too small print when capturing an entire page on screen? With the move to online publishing, it turns out that MYCOTAXON's antediluvian page is exactly the right size for on-screen reading. Some authors have suggested (more or less tactfully) that we should expand to get more text on a page. However, our old-fashioned 11-cm wide, 1-column page turns out to be exactly appropriate for the Modern iPad-Kindle Era, where even the most complex phylotree can be zoomed into legibility when necessary. All hail to the MYCOTAXON page size!

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)

9 March 2014

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October–December 2013

**Biogeography and taxonomy of pyrenomycetous fungi 3.
The area around the Sea of Japan**LARISSA N. VASILYEVA^{1*}, HAI-XIA MA^{2,3} & STEVEN L. STEPHENSON⁴¹*Institute of Biology & Soil Science, Far East Branch of the Russian Academy of Sciences,
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ABSTRACT — The peculiar species composition of the assemblage of pyrenomycetous fungi known from the area around the Sea of Japan is discussed. Three new species—*Annulohypoxylon orientale*, *Hypoxylon cyanescens*, and *Nectria araliae*—are described and illustrated.

KEY WORDS — *Ascomycota*, northeastern Asia, ecological distribution

Introduction

One of the most interesting regions of northeastern Asia is the area around the Sea of Japan. Many pyrenomycetous fungi are restricted to this region of the world, and a number of economically important pathogenic fungi are known only from northeastern China, Japan, Korea and southeastern Russia. Unfortunately, often many of these fungi have been confused with other species, so phytopathologists cannot recognize them and thus develop the appropriate control measures.

At the 2011 Asian Mycological Congress held in Incheon (Korea), Dr. Tsuyoshi Hosoya—during his talk on the reassessment of *Hyaloscyphaceae* (*Helotiales*, *Leotiomycetes*) based on molecular phylogenetic analysis—repeated Dr. Richard Korf's statement that “for the discosystematist, Japan is a relatively unexplored paradise” and that the region is “rich in apparently endemic forms, an understanding of which is essential for phylogenetic and phytogeographic studies” (Korf 1958: 7). However, it seems that not only Japan but rather the entire area around the Sea of Japan is the real ‘paradise’ for many groups of fungi.

Materials & methods

The specimens reported herein are deposited in the Herbarium of Institute of Biology and Soil Science, Far East Branch of the Russian Academy of Sciences (VLA) and the Herbarium of Cryptogams of the Kunming Institute of Botany, Chinese Academy of Sciences (HKAS). Photographs of ascomata were obtained using a Nikon D40x digital camera and S70 Canon camera. The photographs of ascospores were taken by using a VHX-600E microscope of the Keyence Corporation. External stromatal colors were recorded and coded according to Rayner (1970).

Some pathogenic and nonpathogenic pyrenomycetous fungi restricted to the area around the Sea of Japan

One pathogen restricted to the Sea of Japan area is *Venturia nashicola* S. Tanaka & S. Yamam., the scab fungus of Japanese and Chinese pears. Soon after Tanaka & Yamamoto (1964) described this species, its name was reduced to a synonym of *V. pirina* Aderh., which causes a similar disease in European pears (Sivanesan 1977). Although Khokhryakova (1978) had already discussed that *V. nashicola* has shorter ascospores and conidia than *V. pirina*, her studies and special references to their biogeographical differences (Khokhryakova 1978, 1980) were initially ignored, and only recently have her findings been supported by the data obtained by other researchers (Ishii & Yanase 2000). The differences in ascospore size between *V. nashicola* and *V. pirina* (on *Pyrus*) are exactly the same as between *V. chlorospora* (Ces.) P. Karst. and *V. subcutanea* Dearn. (on *Salix*) or *V. canadensis* M.E. Barr and *V. rumicis* (Desm.) G. Winter (on *Rumex*), and if the latter species pairs are accepted as independent (Barr 1968), there seems little reason to unite *V. nashicola* and *V. pirina*.

Another pathogen restricted to the Sea of Japan area is *Polystigma ussuriense* (Jacz. & Natalyina) Prots., first described from the Russian Far East (Natalyina 1931) but not acknowledged until after almost a half century by Khokhryakova (1978, 1980). This species was re-examined even later (Cannon 1996) and accepted as only a subspecies of *P. rubrum* (Pers.) DC. However, even at the level of subspecies the Sea of Japan area has its own taxon. The ascospores and conidia of *P. ussuriense* are longer than those of *P. rubrum* — the same characters separating *Venturia nashicola* and *V. pirina*. Although the same characters have unequal value in different (especially remote) genera, size differences in ascospores and conidia almost universally discriminate species in numerous pyrenomycetous groups (cf. Rappaz 1987; Rossman et al. 1999; Gryzenhout et al. 2009; Jaklitsch 2011). Consequently, *P. ussuriense* might be considered as an independent species occurring in northeastern Asia and probably replaces *P. rubrum* in this area, although the *P. rubrum* has been reported from China, Japan, and Korea (Cannon 1996; Katumoto 2010).

Another example, *Valsa mali* Miyabe & G. Yamada, is a very aggressive pathogen that causes canker of apple trees in various countries surrounding the Sea of Japan. Described more than a century ago (Ideta 1911), *V. mali*

was confused with other species during the past century, most often with *V. ceratosperma* (Tode) Maire (e.g., Kobayashi 1970; Otani 1995), although the two species can be easily distinguished superficially (FIG. 1). The arrangement of ostioles in *V. mali* as a ring around the margin of an ectostromatic disc is characteristic of *Valsa* sect. *Circinatae* (Nitschke 1867; Urban 1957) or sect. *Valsa* (Spielman 1985). The character of an ectostromatic disc filled with closely packed ostioles places *V. ceratosperma* in section *Monostichae*.

The independent status of *V. mali* began to be discussed only relatively recently (Vasilyeva & Kim 2000), although its anamorph, *Cytospora orientis-extremi* Gvrit., had been described (with reference to *V. mali* as the teleomorph) as a separate species even earlier (Gvritishvili 1973). However, the first molecular study to consider *V. mali* (Adams et al. 2002) suggested that it be combined with *Leucostoma persoonii* (Nitschke) Höhn., since the two species clustered together on a phylogenetic tree. Although they look completely different superficially (FIG. 1), the clustering is actually not surprising, given that these two species share a number of similarities (e.g., the kind and size of ascospores, stromatal shape, *Cytospora* anamorphs, restriction to rosaceous hosts). The problem is that those same similarities comprise a repetitive internal polymorphism within *Valsa* and *Leucostoma* and outweigh the few differences that exist between them. When molecular trees are constructed based on phenetic principles, thus relying upon the quantity of shared characters without discriminating their level in the taxonomic hierarchy, such mistakes in the unification of species from different genera are potentially common (Vasilyeva & Stephenson 2010a). A more recent sequence analysis by Wang et al. (2011)

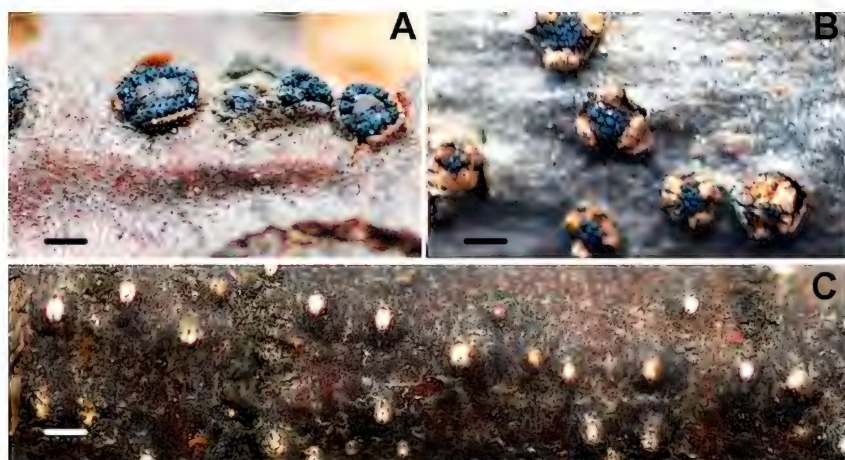


FIG. 1. Stromata. A. *Valsa mali* (VLA P-1981); B. *Valsa ceratosperma* (VLA P-1845); C. *Leucostoma persoonii* (VLA P-230). Scale bars: A, C = 0.5 mm; B = 0.3 mm.

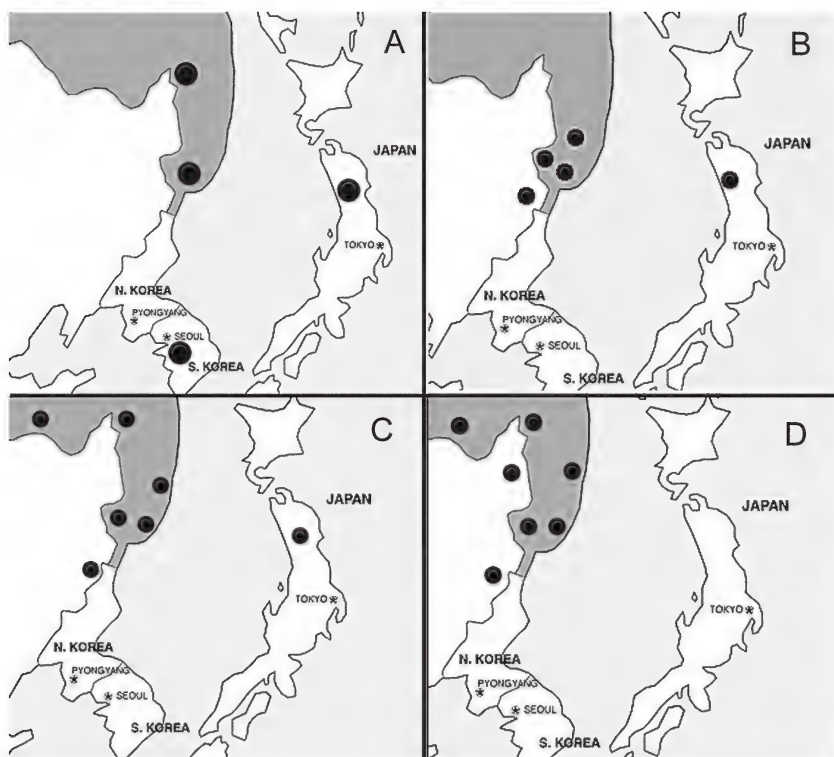


FIG. 2. Known localities of: A. *Biscogniauxia maritima*; B. *Biscogniauxia mandshurica*; C. *Cryptosphaeria venusta*; D. *Cryptosphaeria exornata*. (The map, taken from <http://www.fas.org>, has been modified to show our data).

supports *V. mali* as independent, and its possible distribution in northeastern Asia might be shared with a number of non-pathogenic pyrenomycetous fungi.

Some species described originally from the Russian Far East (Vasilyeva 1998) — *Biscogniauxia mandshurica* Lar.N. Vassiljeva, *B. maritima* Lar.N. Vassiljeva, *Cryptosphaeria exornata* Lar.N. Vassiljeva, *C. venusta* Lar.N. Vassiljeva — were later found in China, Korea or Japan; since their English descriptions and illustrations of stromata have been provided elsewhere (Vasilyeva et al. 2009), only their known localities are presented here (FIG. 2). *Diaporthella corylina* Lar.N. Vassiljeva is known from only two localities in China and Russia, and *Leucodiaporthe acerina* M.E. Barr & Lar.N. Vassiljeva from only two localities in Korea and Russia (Vasilyeva et al. 2007). *Podostroma giganteum* S. Imai, described from Japan (Imai 1932), was reported much later for the Russian Far East.

Among the species reported previously from northeastern Asia (Tsuneda 1982; Tsuneda & Arita 1984; Vasilyeva 1998) in need of taxonomic reconsideration is *Hypoxylon truncatum* (Schwein.) J.H. Mill. As can be seen from FIG. 3, the stromata of '*H. truncatum*' from the Russian Far East surely differ from those observed for *H. truncatum* specimens from the eastern United States; hence we assign the Russian specimens to *Annulohypoxylon orientale*, a new species described herein. In addition, Vasilyeva (1998) reported *Nectria coryli* Fuckel from the southern Russian Far East but emphasized that it had never been found on either of the two *Corylus* species (*C. heterophylla* Fisch. ex Trautv., *C. mandshurica* Maxim.) that are widely distributed in the region. Instead, the fungus was restricted to the *Araliaceae*—mostly to *Aralia elata* (Miq.) Seem. and *Eleutherococcus senticosus* (Rupr. & Maxim.) Maxim.—and was characterized by the presence of black ascomata similar to those of *Nectria austroamericana* (Speg.) Cooke (Samuels et al. 2006), a marked contrast to the red ascomata in *N. coryli*. Ascospores of *Nectria* species from the Sea of Japan area appear even smaller than those characteristic of *N. coryli*. Therefore, on biogeographical, ecological, and morphological grounds, the former warrants being described as the new species *N. araliae*.

The specimens of the third new species described in this paper were repeatedly found in the southern Russian Far East, mostly on *Ligustrina amurensis* (Rupr.) Rupr. (*Oleaceae*), which is distributed throughout northeastern China, Korea, and the Russian Far East. However, the new species was not described until the same fungus was collected in Jilin Province (northeastern China), as discussed in the Ph.D. dissertation by Haixia Ma (Ma 2011), where it was listed as '*Hypoxylon aeneo-viridis*'; herein it is formally named as *H. cyanescens*.

Taxonomy

Annulohypoxylon orientale Lar.N. Vassiljeva & S.L. Stephenson, **sp. nov.** FIG. 3B

MYCOBANK MB 802460

A Annulohypoxylone truncato in disco ostiolato plano ejusdem typi ac A. bovei differt.

TYPE: Russia: Primorsky Territory, Khasan District, Trinity Bay, on dead branches of *Quercus mongolica* Fisch. ex Lebed. (*Fagaceae*), 3 Nov. 1995, L. Vasilyeva (**Holotype** VLA P-382).

ETYMOLOGY: The epithet refers to the eastern part of Asia where this species was collected.

STROMATA solitary to densely aggregated, semi-globose, 2–4 mm diam., 1.3–1.5 mm high, with perithecial mounds $\frac{1}{2}$ – $\frac{1}{4}$ exposed, surface initially brown with shining-black ostiolar caps, then becoming blackened, with KOH-extractable pigments olivaceous (48); the tissue below the perithecial layer blackish. Perithecia spherical, 0.25–0.35 mm diam., ostioles finely papillate, encircled with a flat, *bovei*-type disc 0.2–0.25 mm diam. Asci in the spore-bearing



FIG. 3. Stromata. A. *Annulohypoxyylon truncatum* from Texas, USA (VLA P-2446); B. *Annulohypoxyylon orientale* (VLA P-381). Scale bars: A = 1.2 mm; B = 2.7 mm. (Photo E.M. Bulakh).

portion $70\text{--}80 \times 4.5\text{--}5.5 \mu\text{m}$, stipitate, stipes $30\text{--}50 \mu\text{m}$ long, with an apical ring bluing in Melzer's iodine reagent, discoid, about $1 \mu\text{m}$ broad. Ascospores brown, unicellular, ellipsoid-inequilateral, with narrowly rounded ends, $8\text{--}10 \times 4\text{--}4.5\text{--}(5) \mu\text{m}$, with a straight germ slit shorter than the length of the spore; perispore dehiscent in 10% KOH, smooth.

ADDITIONAL SPECIMENS EXAMINED: RUSSIA: PRIMORSKY TERRITORY, Khasan District, Ryazanovka vicinity, on *Quercus mongolica*, 30 Jun 1982, M. Nazarova (VLA P-381); Trinity Bay, on *Quercus mongolica*, 4 Aug 2006, L. Vasilyeva (VLA P-1803). KOREA: vicinity of Seoul, Suwon, on *Quercus* sp., 30 May 1999, L. Vasilyeva (VLA P-1649)

COMMENTS—In the Russian Far East, this species has been found only in the Khasan District, at the very southern extreme of the Primorsky Territory. It differs from *A. truncatum* (Schwein.) Y.M. Ju et al. in having smaller ostiolar discs that are of the *bovei*-type instead of the *truncatum*-type. The general appearance of the stromata is characterized by the presence of the shining-black and convex ostiolar caps, which persist for a long time but finally fall off to expose the flat ostiolar discs. The image of stromata of a specimen from Japan (Tsuneda & Arita 1984: Fig. 1) corresponds to that noted for specimens from southeastern Russia.

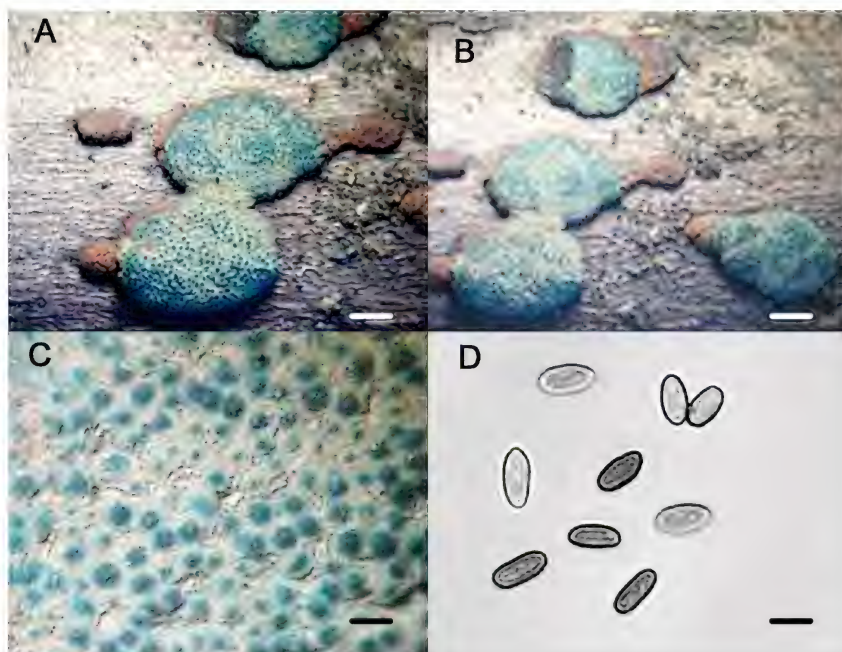


Fig. 4. *Hypoxylon cyanescens*: A-B. Stromata; C. Stromatal surface; D. Ascospores. Scale bars: A = 3.6 mm, B = 2.7 mm, C = 1.4 mm, D = 9.4 μ m.

***Hypoxylon cyanescens* H.X. Ma, Lar.N. Vassiljeva & Yu Li, sp. nov.**

FIG. 4

MYCOBANK MB 802459

A Hypoxylon aeruginoso in ascosporis majoribus et a H. aeruginoso var. macrosporo in granulis in KOH dissolutis differt.

TYPE: China: Jilin Province, Changbai Mountain, alt. 1300 m, on rotten wood, 7 Sept 1998, Pei-gui Liu (Holotype HKAS32650).

ETYMOLOGY: The epithet refers to the color of the stroma.

STROMATA pulvinate or effused-pulvinate, flat or with conspicuous perithecial mounds 2–8 mm diam. and 0.5–1 mm thick; surface brown to dark vinaceous at the sterile margins, dark cyan blue, isabelline or gray olivaceous over the ostiolar portion, later becoming darkened, with KOH-extractable pigments bay (6) to livid purple (81). Perithecia 0.1–0.3 mm, ostioles finely papillate. Asci not observed. Ascospores brown, unicellular, ellipsoid-inequilateral or almost equilateral, with narrowly or broadly rounded ends, $11.5\text{--}13.5 \times 5\text{--}6 \mu\text{m}$, with a straight germ slit extending the length of the spore; perispore indehiscent in 10% KOH, smooth.

ADDITIONAL SPECIMENS EXAMINED: RUSSIA: PRIMORSKY TERRITORY, Lazovsky State Nature Reserve, on *Ligustrina amurensis* (Oleaceae), 2 Aug 1986, L. Vasilyeva (VLA

P-2638); **AMUR REGION**, in the vicinity of Kundur, 24 Aug 1992, L. Vasilyeva (VLA P-2639). **KOREA**: Gangwon province, Pyeongchang county, Mt. Odaesan, 20 Sep 2006, L. Vasilyeva (VLA P-2746).

COMMENTS—*Hypoxyylon aeruginosum* J.H. Mill. and its large-spored variety *H. aeruginosum* var. *macrosporum* J.D. Rogers are the only previously known taxa with a dark cyan blue stromatal surface. Both varieties of *H. aeruginosum* are known from the western hemisphere (Guyana, Mexico, and Louisiana in the United States). *Hypoxyylon cyanesceus* is similar to the large-spored variety of *H. aeruginosum* in ascospore size but differs in the presence of bay to livid purple KOH-extractable pigments, whereas the latter variety has stromata apparently without KOH-extractable pigments.

Nectria araliae Lar.N. Vassiljeva & S.L. Stephenson, **sp. nov.**

MYCOBANK MB 802461

A Nectria coryli in ascosporis minoribus et ascomatis nigrescentibus differt.

TYPE: Russia: Primorsky Territory, Khasan District, Kedrovaya Pad Nature Reserve, on *Aralia elata* (*Araliaceae*), 25 Oct 1987, L. Vasilyeva (**Holotype** VLA P-1383).

ETYMOLOGY: The epithet refers to the host genus of the holotype specimen.

ASCOMATA crowded in clusters, superficial or slightly embedded on a stromatic basis, dark-grey or black, globose to turbinate, becoming collapsed when dry, smooth, 200–250 µm diam., with small papillate ostioles. Asci cylindrical, 70–80 × 4–4.5 µm. Ascospores biserial, two-celled, about 8–10 × 3–4 µm, with small setose appendages, usually budding in the asci.

ADDITIONAL SPECIMENS EXAMINED: **RUSSIA, PRIMORSKY TERRITORY**, Ussuriysk District, Mountain-Taiga Station, on *Aralia elata*, 23 Sep 1984, M. Gvritschvili (VLA P-1993); Sikhote-Alin Nature Biosphere Reserve, on *A. elata*, 3 Aug 1985, L. Vasilyeva (VLA P-1381); **KURILE ISLANDS**, Kunashir Island, on *A. elata*, 31 Jul 1987, L. Vasilyeva (VLA P-1386); **KHABAROVSK TERRITORY**, Komsomolsk Nature Reserve, on *Eleutherococcus senticosus*, 2 Jul 1986, L. Vasilyeva (VLA P-2139); **JEWISH AUTONOMOUS REGION**, Bastak Nature Reserve, on *E. senticosus*, 19 Aug 2004, L. Vasilyeva (VLA P-2124).

COMMENTS—The similarity of *Nectria araliae* with *N. coryli* is impressive, and the ascospores have setose appendages and are usually budding in both species. Only recently, the ecological preferences of the north-Asian specimens and their distribution peculiarities were taken into consideration. Superficially, the black ascomata of *N. araliae* are similar to those of *Nectria austroamericana* (Samuels et al. 2006: photo on p. 120), but the latter seems to be restricted to members of the *Fabaceae* (*Acacia* and *Gleditsia*), has ascospores that are irregularly septate, with 3–6-transverse and one longitudinal septa, and has been reported for North and South America.

Discussion

The area considered in this paper is known as “the Eastern Asiatic Region (Oriasiaticum, Sino-Japanese Region, East Asian Region, Temperate Eastern Region)” and has been described as “the richest floristic region within the Holarctic Kingdom situated in temperate East Asia.” Moreover, “it has been recognized as a natural floristic area since the publication in 1872 of August Grisebach’s volume ‘Die Vegetation der Erde’ and was later delineated by such geobotanists as Ludwig Diels, Adolf Engler (as the Temperate Eastern region), Ronald Good (as the Sino-Japanese Region), and Armen Takhtajan” (<http://en.wikipedia.org>).

This special center of biodiversity is said to comprise “the southern part of the Russian Far East, southern part of Sakhalin, Manchuria, Korea, Japan, Taiwan, the relatively humid eastern part of mainland China extending from Manchuria and the coastline to the Eastern Himalaya and Kali Gandaki Valley in Nepal, including Sikkim, northern Burma (Myanmar) and northernmost Vietnam (parts of Tonkin)” (<http://en.wikipedia.org>). Although knowledge of the mycobiota in many of the countries in southern Asia (such as Burma or Vietnam) is rather poor, the scattered data reported in the rather limited literature and our preliminary observations indicate that the fungal biodiversity in countries (e.g., China, Japan, Korea, and southeastern Russia) located around the Sea of Japan differs from that of more southern portions of this world region. Moreover, it also should be noted that some current studies of vegetation also exclude the south of China, Burma, and Vietnam from the Sino-Japanese Floristic Region (Yih 2012: map at p. 16). It seems that the apparently unique area in question is primarily limited by the distribution in northeastern Asia of what are referred to as ‘cool-temperate rainforests’ (Krestov et al. 2011; Nakamura et al. 2011), whereas the excluded countries are characterized by different types of climate and vegetation.

Many pyrenomycetes have been collected exclusively in the Sea of Japan area and assigned to new species or genera (Vasilyeva 1990, 1993, 2001, 2007, 2010; Ju et al. 1999, 2009; Stadler et al. 2005; Vasilyeva & Mel’nik 2006; Vasilyeva & Stadler 2008; Vasilyeva et al. 2007, 2010; Hirooka et al. 2011). The main purpose of the Vasilyeva & Stephenson (2010b, 2011) series (for which this is the third contribution) is to emphasize that by neglecting biogeographical patterns, mycologists often have reached the wrong conclusions regarding application of species names to fungi in northeastern Asia. For example, *Cryptosphaeria eunomioides* (G.H. Otth) Höhn., *Diatrype disciformis* (Hoffm.) Fr., *Diatrypella quercina* (Pers.) Cooke, *Hypoxylon fragiforme* (Scop.) J. Kickx f., and *Rosellinia aquila* (Fr.) Ces. & De Not. have all been reported from the Russian Far East

(e.g., Koval 1972) but actually do not occur there, and any of these names applied to Chinese fungi (Teng 1996) should be checked.

It is possible that species restricted to the Sea of Japan area had a wider distribution prior to the Glacial Age but were pushed by glaciers to the edge of the Pacific Ocean where the Sea of Japan formed after separation of the island arc of Japan from the Asian mainland about 20 million years ago. It is possible that this area became a kind of 'trap' for fungi that depend upon air currents for spore dispersal, whereas the air currents themselves often depend upon sea currents. If one looks at the map of sea currents around the Japanese Archipelago (<http://valeriecourreges.blogspot.com>), one can see that the main water circulation pattern in the Sea of Japan is created by two main currents, with the Tsushima Current being warm and the Liman Current being cold. In fact, these two currents create a closed system of water as well as the air currents responsible for transferring fungal spores. The partial exit from this closed system toward Sakhalin Island and the southern Kurile Islands is provided by the Soya Current. This might explain why some fungal species (e.g., *Loranitschkia viticola* Lar.N. Vassiljeva, *Nectria araliae*) are known not only from the Asian mainland near the Sea of Japan but also from Kunashir Island.

Only a few species have distribution patterns that extend southward from the Sea of Japan area, and the currents around the Japanese Archipelago are probably responsible for this distribution, too. The prevailing winds associated with the warm waters of the Kuroshio Current, which begin along the eastern shores of Taiwan, might carry fungal spores to Japan, and there are interesting examples of distribution patterns that extend along the eastern coast of Asia from the Kurile Islands to an area of the mainland at approximately the same latitude as Taiwan. For example, *Spirodecospora melnikii* (Lar.N. Vassiljeva) K.D. Hyde & Melnik, described from Kunashir Island (Vasilyeva 1990: as *Anthostomella melnikii*), also has been found in Korea (Mel'nik et al. 2005) and near Hong Kong (Lu et al. 1998). The Hong Kong fungus was described originally as *Spirodecospora bambusicola* B.S. Lu et al., now regarded as a synonym of *S. melnikii* (Mel'nik & Hyde 2003). The mainland coastline of China is mentioned above as one characteristic area of the Sino-Japanese Floristic Region, and further investigations may reveal a whole complex of species with the same distribution.

Similar distributional regularities also occur in a very distantly related group of fungi. Fifty-three of 123 rust species (43%) found in Russia belonging to *Chaconiaceae*, *Coleosporiaceae*, *Cronartiaceae*, *Melampsoraceae*, *Mikronegeriaceae*, *Phakopsoraceae*, and *Pucciniastraceae* are restricted to the Sea of Japan area (Azbukina & Karatygin 2010). Within this group, a number of species seem to have had their spores carried by the air current associated

with the Soya Current from Japan to Sakhalin Island and southern Kurile Islands. Consequently, *Coleosporium yamabense* (Saho & I. Takah.) Hirats. f., *Naohidemycetes fujisanensis* S. Sato et al., and *Uredinopsis woodsiae* Kamei are shared by Japan and Sakhalin Island (Azbukina 2005); *Pucciniastrum hydrangeae-petiolaris* Hirats. f. is known from Japan, Sakhalin Island, and Kunashir Island; *Thekopsora tripetaleiae* Hirats. f. has been reported from Japan and Iturup Island; and *T. menziesiae* Hirats. f. is known from Japan, Kunashir Island, and Iturup Island. The Taiwanese connection is also found in the rust fungi: *Blastospora itoana* Togashi & Onuma and *Milesina miyabei* Kamei are found both in the Sea of Japan area (China, Japan, the southern portion of the Russian Far East) and Taiwan (Ono et al. 1987; Azbukina 2005).

Zoogeographical studies clearly also distinguish the so-called ‘Sino-Japanese realm’ (Holt et al. 2013). This realm does not encompass such southern countries as Burma, Nepal, or Vietnam but extends further to the west of northern China than suggested for the center of fungal biodiversity around the Sea of Japan. In this context, a rather interesting fungus described recently by Zhuang & Bau (2008), namely *Sinofavus allantosporus* W.Y. Zhuang & T. Bau, merits attention. One specimen was collected in 2003 in the Magadan region (north-eastern Russia) by Nina Sazanova and sent to Larissa Vasilyeva but not described. A second collection found again in 2007 by Tolgor Bau in the westernmost Chinese province of Xinjiang (Tuomer Peak) was designated as the holotype of the species. *Sinofavus allantosporus* seems to be restricted to *Populus* species, the substrate of the Nina Sazanova specimen; the illustration provided in Zhuang & Bau (2008: Fig. 1) shows the branch (apparently from *Populus*) upon which the Chinese specimen fruited. As such, a double restriction—first to substrate and then to the northern mountainous region of northeastern Russia and northern China—is characteristic of *S. allantosporus*, and it is extremely surprising that such a peculiar discomycete with compound fruitbodies remained completely unnoticed until the 21st century. All these preliminary observations indicate the need for further investigation of several species complexes in north-eastern Asia that appear to have their own biogeographical patterns.

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Hyphomycetes: *Linodochium sinense* sp. nov. and new records from fallen *Sycopsis sinensis* leaves in ChinaDE-WEI LI^{*1}, JINGYUAN CHEN² & YIXUN WANG²¹*The Connecticut Agricultural Experiment Station, Valley Laboratory,
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ABSTRACT — Among hyphomycetes collected from dead leaves of *Sycopsis sinensis* in Houhe National Nature Reserve, Wufeng, Hubei, China, a sporodochial fungus new to science, *Linodochium sinense*, is described and illustrated. It develops yellow conidiomata and 2-celled conidia that are filiform, colorless, smooth, $34\text{--}40 \times 1.1\text{--}1.5\ \mu\text{m}$. *Candelabrum microsporum*, *Chalara affinis*, *Cylindrocladium madagascariense*, and *Subulispora britannica* are new records from China, while *Menisporopsis novae-zelandiae* is newly reported from mainland China.

KEY WORDS — anamorphic fungi, saprobe

Introduction

Houhe National Nature Reserve in Wufeng Tujia Autonomous County, Hubei, China is exceptional for its rich biodiversity and rare species. With over 2292 species of vascular plants including 29 endangered species (Song & Liu 1999, Li et al. 2005), the Reserve also possesses some species native only to China (Dang et al. 2004, Li et al. 2005). Its fungal diversity is almost entirely unexplored, and only two studies (on ascomycetes and polypores) have been conducted there (Li et al. 2007, Zhuang et al. 2007).

Sycopsis sinensis Oliv. (*Hamamelidaceae*) is a native evergreen broadleaf woody plant that grows sporadically in mixed evergreen broadleaf forests or bushes at elevations of 1000–2000 m in southern China (Li et al. 2003). The largest population of *S. sinensis* as dominant species has been reported in Houhe National Nature Reserve (Liu et al. 1999).

Two field trips were made to the Reserve to collect hyphomycetes in August 2008 and May 2009. Hyphomycetes on dead leaves of *S. sinensis* were studied

and categorized. Three new hyphomycetes from the two surveys have already been published, one of them from *S. sinensis* (Li et al. 2010, Li et al. 2011). Five additional hyphomycetes from *S. sinensis* are reported here, one as a new species, three as new records from China, and one as a new record from mainland China.

Materials & methods

Sporodochia, conidiophores and conidia of the fungus were mounted in lacto-fuchsin (0.1 g acid fuchsin, 100 ml 85% lactic acid; Carmichael 1955) or 85% lactic acid. Microscopic observations were made using bright field and Nomarski differential interference contrast optics. Photomicrographs were taken with an Olympus MicroFire digital camera (Goleta, CA). Fungal structures were measured with PictureFrame 2.3 software (Goleta, CA). Measurements of the fungal structures were statistically analyzed with Microsoft Office Excel 2010 with 95% confidence interval of means. The results are presented as ranges and mean $\pm$ standard deviation. Q = length/width ratio and n = the number of fungal structures measured. Herbarium acronyms follow Index Herbariorum (Thiers 2013).

Taxonomy

Linodochium sinense D.W. Li, Jing Y. Chen & Yi X. Wang, **sp. nov.**

FIGS 1–6

MYCOBANK MB 804385

Differs from other *Linodochium* spp. by conidiogenous cells that bear 1–3 (mostly 2) 1-septate conidia with dichotomous denticulate apices and conidial anastomoses that form x-shaped derivative conidia.

TYPE: China, Hubei, Wufeng, Houhe National Nature Reserve, on dead leaves of *Sycopsis sinensis*, 20 May 2009, Yixun Wang (**Holotype**: BPI 892531).

ETYMOLOGY: referring to China for its origin.

CONIDIOMATA sporodochial, circular to irregular, bright yellow when young, orange at maturity, scattered, hypophyllous, occasionally amphigenous, 200–300 μm diam. and 90–110 μm high. CONIDIOPHORES differentiated, erect, branched, flexuous or straight, colorless to pale yellow, smooth, septate, packed together. CONIDIOGENOUS CELLS integrated, terminal, holoblastic, straight or flexuous, bacilliform or ampulliform, sympodially elongated, smooth, thin-walled, colorless, $(11\text{--})12\text{--}16(\text{--}19) \times (1\text{--})1.2\text{--}1.4(\text{--}1.7) \mu\text{m}$ (mean = $14.4 \pm 1.8 \times 1.3 \pm 0.1$, $n = 30$), bearing mostly (1–)2(–3) conidia; apices of some conidiogenous cells ending with two flat-topped denticles of different lengths

FIGURES 1–8. *Linodochium sinense* (Holotype: BPI 892531). 1. Sporodochia on lower epidermis of a leaf of *Sycopsis sinensis*, 2. Cross-sections of sporodochia. 3. Conidiogenous cells and conidiophores. 4. Conidia on conidiogenous cells and four pairs of conidia on the right anastomosed into x-shaped derivative conidia. 5. An x-shaped derivative conidium. 6–7. Conidia on a conidiogenous cell with a dichotomous denticulate apex. 8. Three conidia on a conidiogenous cell with a trichotomous denticulate apex. Scale bars: 1 = 1 mm; 2 = 10 μm ; 3–8 = 5 μm .



forming a dichotomy, some with one denticle and one flat conidiogenous locus on the other side of the conidiogenous cell apex, rarely, conidiogenous cells ending in a trichotomous denticulate apex. CONIDIA 1-septate, filiform, colorless, smooth, guttulate, $(32-34-40(-45) \times (1-)1.1-1.5(-1.6) \mu\text{m}$ (mean = $37.5 \pm 3 \times 1.3 \pm 0.2$, $n = 30$), $Q = (22.5-)24.5-32.1(-39.3)$ (mean = 28.3 ± 3.8 , $n = 30$); some conidial pairs anastomosing to form x-shaped derivative conidia.

TELEOMORPH: unknown.

GEOGRAPHICAL DISTRIBUTION: Hubei, China.

HABITAT: dead leaves of *Sycopsis sinensis*.

NOTES: *Linodochium* was erected by Höhnelt (1909) and typified by *Linodochium hyalinum* (Lib.) Höhn. It remained monotypic for seven decades. Dyko & Sutton (1979) redescribed and illustrated the genus and *L. hyalinum*, its only species. Two years later, Minter & Holubová-Jechová (1981) added a second species, *L. formosum* Minter & Hol.-Jech. During the 1990's two more species were described: *Linodochium album* R.F. Castañeda & W.B. Kendr. (Castañeda & Kendrick 1990) and *L. hyalinum*, *L. sideroxyli* Dulym. et al. (Dulymamode et al. 1999). *Linodochium sinense* is the fifth species proposed in the genus. Much longer conidia differentiate *L. formosum* (80–140 μm with 2–4 septa; Dyko & Sutton 1979) and *L. hyalinum* (36–89 μm with <12 septa; Minter & Holubová-Jechová 1981) from *L. sinense*. White sporodochia and falcate conidia of *L. album* (Castañeda & Kendrick 1990) differ from the yellow sporodochia and filiform conidia of *L. sinense*. *Linodochium sideroxyli* is morphologically similar to *L. sinense* but differs in having wider conidia (1.5–2 μm , to 2.5 μm at the apex, 0–1 septum; Dulymamode et al. 1999) without dichotomous denticulate apices.

The significance of conidial anastomosis to form x-shaped derivative conidia in *L. sinense* is not clear. It might function as parasexual behavior or as part of sexual reproduction. However, further study is necessary to determine its function.

The teleomorph of *L. hyalinum* was found to be *Pseudohelotium pineti* (Batsch) Fuckel (Minter & Holubová-Jechová 1981). However, we found no teleomorph for *L. sinense*.

There are no DNA sequence data for any *Linodochium* species deposited in GenBank, and we were unable to isolate DNA from the *L. sinense* type specimen.

Key to species of *Linodochium*

- | | |
|--|--------------------|
| 1. Sporodochia yellow, amber, or orange | 2 |
| 1. Sporodochia white to grayish white | 4 |
| 2. Conidia 2–4-septate, $36-89 \times 1-1.5 \mu\text{m}$ | <i>L. hyalinum</i> |
| 2. Conidia 0–1-septate | 3 |

3. Conidiogenous cells bearing 1–4 conidia, no denticles at apical end;
conidia 0–1-septate, $32\text{--}48 \times 1.5\text{--}2\ \mu\text{m}$, wider toward apex *L. sideroxyli*
3. Conidiogenous cells bearing mostly 2 conidia, with dichotomous denticles at apex;
conidia 1-septate, $34\text{--}40 \times 1.1\text{--}1.5\ \mu\text{m}$, conidial anastomosis forming x-shaped
derivative conidia *L. sinense*
4. Conidia straight, <12 -septate, $80\text{--}140 \times 2\text{--}3\ \mu\text{m}$ *L. formosum*
4. Conidia falcate, 1–2-septate, $30\text{--}45 \times 1\text{--}2\ \mu\text{m}$ *L. album*

New records for China

Candelabrum microsporum R.F. Castañeda & W.B. Kendr., Univ. Waterloo Biol. Ser. 35: 16 (1991)

TELEOMORPH: unknown.

CONIDIOPHORES reduced to conidiogenous cells. CONIDIOGENOUS CELLS monoblastic. CONIDIA subhyaline, solitary; conidial body multi-branched dichotomous or sometimes trichotomously, with minute apical tubercles, forming globose, subglobose or elongated conidia, $35\text{--}55\ \mu\text{m}$ diam.

SPECIMEN EXAMINED: CHINA, HUBEI, Wufeng, Houhe National Nature Reserve, dead leaf of *Sycopsis sinensis*, 28 August 2008, De-Wei Li (BPI 892532).

ECOLOGY & DISTRIBUTION: On dead leaves of *Sycopsis sinensis*; *Palmae*. Previously known from Cuba; new record from China.

NOTE: Some conidia from the Chinese specimen are elongated and deviate slightly from the conidial shape of the holotype. Zhao et al. (2007) reported two other *Candelabrum* species in China, *C. brochiatum* Tubaki and *C. spinulosum* Beverw. Both species were collected on decaying branches of an undetermined tree submerged in water in Dashuwang, Mount Tianmu, Zhejiang.

Chalara affinis Sacc. & Berl., Atti Ins. Veneto Sci. Lett., Arti, Ser. 6 3: 741 (1885)

TELEOMORPH: unknown.

CONIDIOPHORES simple, erect, straight or slightly flexuous, cylindrical with an inflated base, <4 septate, sometimes constricted at the septa, pale brown, smooth, $40\text{--}70\ \mu\text{m}$ long, $4\text{--}6\ \mu\text{m}$ wide at the base. PHIALIDES lageniform, pale brown, smooth, $35\text{--}50 \times 4\text{--}6.5\ \mu\text{m}$. CONIDIA 1-celled, colorless, smooth, cylindrical, ends flat or slightly rounded, $8\text{--}11 \times 1.5\text{--}2\ \mu\text{m}$, catenate.

SPECIMEN EXAMINED: CHINA, HUBEI, Wufeng, Houhe National Nature Reserve, dead leaf of *Sycopsis sinensis*, 28 August 2008, De-Wei Li (BPI 892533).

ECOLOGY & DISTRIBUTION: On dead leaves of *Sycopsis sinensis*; *Pinus sylvestris* (Minter & Holubová-Jechová 1981). Previously known from Czech Republic and the United Kingdom; new record from China.

NOTE: the conidia from the Chinese material are slightly smaller than those of the type.

Cylindrocladium madagascariense Crous, Tax. Path. *Cylindrocladium*: 112 (2002)

TELEOMORPH: *Calonectria madagascariensis* Crous.

CONIDIOPHORES colorless, smooth, penicillate, $60\text{--}85 \times 5\text{--}6.5\text{ }\mu\text{m}$, with a septate extension, $130\text{--}350\text{ }\mu\text{m}$ long, terminating in a clavate vesicle. PHIALIDES, colorless, smooth, allantoid, cylindrical, or doliiform, $9\text{--}11 \times 3\text{--}4\text{ }\mu\text{m}$. CONIDIA cylindrical, rounded at both ends, straight, colorless, smooth, thin-walled, 3-septate, $50\text{--}55 \times 4\text{--}5\text{ }\mu\text{m}$.

SPECIMEN EXAMINED: CHINA, HUBEI, Wufeng, Houhe National Nature Reserve, dead leaf of *Sycopsis sinensis*, 20 May 2009, Yixun Wang (BPI 892534).

ECOLOGY & DISTRIBUTION: On fallen leaves of *Sycopsis sinensis*; *Eucalyptus* sp., soil. Previously known from Congo and Madagascar (Crous 2002); new record from China.

NOTES: The Chinese collection had shorter conidiophore extensions and slightly shorter conidia than those of the holotype. Crous (2002) reported that *Cylindrocladium madagascariense* is pathogenic to *Eucalyptus* sp., causing a leaf spot. It remains unknown whether this species does the same to *S. sinensis*. Further observation of *S. sinensis* foliage prior to leaf abscission is necessary to clarify this.

Subulispora britannica B. Sutton, Trans. Br. Mycol. Soc. 61(3): 422 (1973)

TELEOMORPH: unknown.

CONIDIOPHORES $20\text{--}40 \times 3.5\text{--}4\text{ }\mu\text{m}$, differentiate, solitary, straight or flexuous, 1–4 septate, smooth, thick-walled, pale brown to brown, sometimes with an enlarged base. CONIDIOGENOUS CELLS integrated, terminal polyblastic, sympodial, subhyaline to pale brown, thin-walled with 1–3 conspicuous flat unthickened scars. CONIDIA solitary, 3–10-septate, colorless, filiform, straight, thin-walled, smooth, $50\text{--}90\text{ }\mu\text{m}$ long and $2.5\text{--}3\text{ }\mu\text{m}$ wide at the base, attenuated toward the apex.

SPECIMEN EXAMINED: CHINA, HUBEI, Wufeng, Houhe National Nature Reserve, dead leaf of *Sycopsis sinensis*, 28 August 2008, De-Wei Li (BPI 892535).

ECOLOGY & DISTRIBUTION: on dead leaves of *Sycopsis sinensis*; *Hedera helix*, *Ilex aquifolium*, *I. pernyi*, and *Quercus suber* (Kirk 1982). Previously known from Russia and UK; new record from China.

NOTES: The Chinese conidiophores and conidia are slightly longer than those of the type.

New record for Mainland China

Menisporopsis novae-zelandiae S. Hughes & W.B. Kendr., N.Z. J. Bot. 6: 369 (1968)

TELEOMORPH: unknown.

SETAE solitary, dark brown, pale brown toward the apex, <17 septate, $250\text{--}400\text{ }\mu\text{m}$ long, $8\text{--}14\text{ }\mu\text{m}$ at the base. CONIDIOPHORES $40\text{--}75 \times 1.5\text{--}2\text{ }\mu\text{m}$.

CONIDIOGENOUS CELLS monophialidic, smooth, colorless or subhyaline, straight or slightly curved, $15\text{--}20 \times 3\text{--}4 \mu\text{m}$. COLLARETTE conspicuous, infundibuliform or cupulate, $2\text{--}3 \mu\text{m}$ wide, $1.5\text{--}3.5 \mu\text{m}$ deep. CONIDIA 1-septate, allantoid, colorless, smooth, $16\text{--}20 \times 2.5\text{--}3 \mu\text{m}$ with a simple setula at each end, $4\text{--}6 \mu\text{m}$ long.

SPECIMEN EXAMINED: CHINA, HUBEI, Wufeng, Houhe National Nature Reserve, dead leaf of *Sycopsis sinensis*, 20 August 2009, Yixun Wang (BPI 892536).

ECOLOGY & DISTRIBUTION: on dead leaves of *Sycopsis sinensis*; *Beilschmiedia tarairi*, *Cinnamomum osmophloeum*, *C. pedunculatum*, *C. zeylanicum*, *Cryptocarya mackinnoniana*, *Knightia excelsa*, *Litsea japonica*, palm, *Pasania edulis*, *P. kawakamii* (Hughes & Kendrick 1968, Matsushima 1980, 1989, 1993). Previously known from Australia, Ecuador, Japan, New Zealand (Matsushima 1975, 1980, 1989, 1993). This is the first report from Mainland China. Matsushima (1980) reported this species from Taiwan.

NOTES: The Chinese collection had shorter setae than those of the type and its conidiogenous cells are not polyphialidic.

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***Colletotrichum fruticicola*, first record of bitter rot of apple in China**DAN-DAN FU^{1, 2}, WEI WANG¹, RUI-FENG QIN¹, RONG ZHANG^{1A*},
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ABSTRACT — *Colletotrichum fruticicola*, isolated from diseased apple fruit with bitter rot symptoms collected in orchards of Henan Province, is a new record for China. It also represents a new pathogen species for apple bitter rot. Phylogeny inferred from combined data sets of the complete rDNA ITS1-5.8S-ITS2 region, partial actin (ACT), β -tubulin-2 (TUB2) and glyceraldehyde-3-phosphate dehydrogenase (GPDH) confirmed that the fungus should be included within *C. fruticicola*, and this grouping was also congruent with morphology and culture characteristics.

KEY WORDS — anamorph, molecular, taxonomy, pathogenicity

Introduction

A worldwide fungal disease, bitter rot of apple, can cause serious economic loss. Since 1990, the major pathogens causing bitter rot were reported as *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. and its teleomorph, *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk; *C. acutatum* J.H. Simmonds plays a relatively minor role (González et al. 2006).

Colletotrichum is one of the most economically important fungal genera (Hyde et al. 2009a). *Colletotrichum* species are cosmopolitan; multiple species can occur on a single host, and a single species is often found on multiple hosts (Cai et al. 2009). Sutton (1992) noted that morphology alone is not sufficient for a precise identification because the lack of reliable morphological features makes species boundaries ambiguous and confusing, especially in the *C. acutatum*, *C. gloeosporioides*, and *C. dematium* complexes. Reliable species identification is important for biosecurity, plant breeding, and integrated disease management.

Since 2009, MycoBank has recorded 28 new *Colletotrichum* species, including six previously considered to belong to the *C. gloeosporioides* complex. One species, *C. fructicola* isolated from coffee berries in Thailand, was separated from *C. gloeosporioides* complex by Prihastuti et al. (2009) based on multi-gene phylogeny and morphological characters.

In China, *C. gloeosporioides* was assumed to be the sole pathogen causing apple bitter rot (Wang & Li 1987) until Zhang et al. (2008) reported that *C. acutatum* could also cause the disease. In order to identify the *Colletotrichum* species causing bitter rot of apple in China, we collected and isolated the pathogen from diseased apple fruit in orchards in Henan Province in 2011 and 2012.

Materials & methods

Isolates & morphology

Apple orchards in Henan Province, China were surveyed for bitter rot symptoms in the autumn of 2011 and 2012. A small piece of decayed tissue was cut from arbitrarily selected lesions on fruits and disinfected with 70% ethanol before placed on potato dextrose agar (PDA). Four strains were isolated and incubated at 28°C in darkness for 7 days on PDA. A mycelial disc was then removed from the actively growing edge of a mono-conidial colony and transferred to new PDA. Three replicate cultures of each isolate were investigated. After 7 days at 25°C in darkness, size and shape of 50 conidia were measured (Than et al. 2008), and the colony diameter, conidial mass colors, and colony zonations were also recorded. Appressoria were produced using a slide culture technique, in which a 1 cm² segment of PDA containing the isolate was placed in sterile water in a sterile Petri dish, covered with a sterile cover slip, and incubated under high humidity at 25°C in darkness. After 2 days, the shape and size of 50 appressoria on the cover slip were recorded. The F11PGZH03 living culture was deposited in China General Microbiological Culture Collection Center (CGMCC), Beijing, China.

DNA extraction & PCR sequencing

The protocol of Barnes et al. (2001) was used to extract genomic DNA from mycelium growing on PDA. The primers ITS1-F and ITS4 were used to amplify the ITS region of rDNA. The ACT gene was amplified with primer pair ACT512F and ACT783R; TUB2 with Bt2a and Bt2b; and GPDH with GDF1 and GDR1 (Prihastuti et al. 2009). The amplification conditions of PCR reactions were: initial denaturation at 95°C for 3 min followed by 34 cycles of denaturation at 95°C for 60 s, annealing at 52°C for 30 s, extension at 72°C for 1 min and a final cycle of 10 min at 72°C. The PCR products were sequenced by Sangon Biotech Co., Shanghai China, and the results were manually checked for errors.

Phylogenetic analysis

Sequence data from ITS, ACT, TUB2, and GPDH genes of our isolate were deposited in GenBank and compared with other *Colletotrichum* sequences from GenBank

TABLE 1. *Colletotrichum* sequences used in the phylogenetic analysis

SPECIES / STRAIN*	GENBANK ACCESSION NUMBERS*			
	ITS	ACT	TUB2	GPDH
<i>C. asianum</i> BML I3 ¹	FJ972605	FJ903188	FJ907434	FJ972571
BPD I4 ¹	FJ972612	FJ907424	FJ907439	FJ972576
<i>C. falcatum</i> FAL ¹	FJ972606	FJ907431	GQ289454	FJ972585
<i>C. fructicola</i> BPD II2 ¹	FJ972611	FJ907425	FJ907440	FJ972577
BPD II6 ¹	FJ972603	FJ907426	FJ907441	FJ972578
F11PGZH03 ²	KC012513	KC012505	KC012517	KC012509
<i>C. gloeosporioides</i> CBS 953.97 ¹	FJ972609	FJ907430	FJ907445	FJ972582
<i>C. hymenocallidis</i> CSSN2 ³	GQ485600	GQ856775	GQ849438	GQ856757
CSSN3 ³	GQ485601	GQ856776	GQ849439	GQ856759
<i>C. kahawae</i> IMI 319418 ¹	FJ972608	FJ907432	FJ907446	FJ972583
IMI 363578 ¹	FJ972607	FJ907433	FJ907447	FJ972584
<i>C. siamense</i> BPD I2 ¹	FJ972613	FJ907423	FJ907438	FJ972575
BML I15 ¹	FJ972614	FJ907422	FJ907437	FJ972574
<i>C. simmondsii</i> BRIP 28519 ⁴	FJ972601	FJ907428	FJ907443	FJ972580

*Type strains and sequences in bold font

¹Prihastuti et al. (2009); ²this paper; ³Yang et al. (2009); ⁴Hyde et al. (2009b).

(TABLE 1), including those of several type specimens (Hyde et al. 2009b, Prihastuti et al. 2009, Yang et al. 2009). Preliminary alignments of the four gene sequences were conducted using Clustal X (Thompson et al. 1997) with manual adjustment, and using BioEdit for visual improvement wherever necessary. Phylogenetic analysis of the combined ITS/ACT/TUB2/GPDH sequences was performed using PAUP (Phylogenetic Analysis Using Parsimony) v. 4.0b10 (Swofford 2003). All characters were unordered and of equal weight and gaps were treated as missing data. Clade stability of the tree resulting from maximum parsimony analysis (MP) and neighbor-joining analysis (NJ) was evaluated by 1000 bootstrap replications on the same aligned dataset (Hillis & Bull 1993). Measures calculated for parsimony included tree length (TL), consistency index (CI), retention index (RI), and rescaled consistency index (RC). The outgroup was *Colletotrichum falcatum*.

Pathogenicity testing

The spores of isolate F11PGZH03 were harvested from PDA cultures, and the concentration of spore suspension in sterile water was adjusted to 10⁶ conidia/ml using a haemocytometer. Mature and non-wounded Fuji apple fruits were surface-sterilized with 70% ethanol prior to inoculation. Apples were inoculated by using wound/drop and non-wound/drop inoculation methods (Prihastuti et al. 2009). The isolate inoculation was repeated three times. Control fruits were treated similarly to the inoculated fruit, but with sterile water instead of spore suspension. After inoculation, the fruits were placed in a closed plastic bag to maintain high humidity and held at 25°C in the darkness. The length and width of typical symptoms on the skin of fruit were recorded after 5 and 10 days.



FIG. 1. *Colletotrichum fructicola* (F11PGZH03). A–B, colony on PDA after 7 days, (A = upper; B = reverse). C, bitter rot symptom on apple skin. D–E, conidia. F–H, appressoria. Bars: D–H = 10 μ m.

Results

Taxonomy

Based on morphological, cultural, and multigene phylogenetic data, the isolates were identified as:

Colletotrichum fruticicola Prihastuti, L. Cai & K.D. Hyde, Fungal Diversity 39: 96. 2009. FIG. 1

SEXUAL MORPH not observed. ASEXUAL MORPH on PDA. HYPHAE hyaline, smooth-walled, septate, branched. CONIDIOPHORES formed directly on hyphae. SETAE not observed. CONIDIA hyaline, smooth-walled, aseptate, straight, cylindrical with both ends round or one end slightly acute, $(12.3-15.5(-17.1) \times (4.3-4.7-5.5(-6.3) \mu\text{m}$, mean $\pm$ SD = $14.59 \pm 1.16 \times 5.11 \pm 0.38$, L/W ratio = 2.9. APPRESSORIA single or in loose groups, pale to dark brown, ovoid and slightly irregular to irregular in shape and often becoming complex with age, $(6.4-7-9(-10.5) \times (4.7-5.2-6.2(-6.9) \mu\text{m}$, mean $\pm$ SD = $8.08 \pm 1.03 \times 5.78 \pm 0.54$, L/W ratio = 1.4.

CULTURAL CHARACTERISTICS — Colonies grown from single conidia on Difco PDA 78–80 mm diam after 7 d. Aerial mycelium white to pale grey, dense, cottony, surface of agar pale grey to dark grey towards centre, more of less white at the edge; acervuli not observed. In reverse grayish green towards centre with white halo. In 7 days at 28°C, growth rate 8.5–9.25 mm/day (mean $\pm$ SD = 9.06 ± 0.375 , n = 9).

SPECIMENS EXAMINED: CHINA, HENAN PROVINCE: ZHENGZHOU CITY, on fruit surface of apple (*Malus domestica* Baumg.), 28 Sept. 2011, Dandan Fu F11PGZH03 (living culture, CGMCC 3.15207; GenBank KC012513, KC012505, KC012517, KC012509); SHANGQIU CITY, 6 Sept. 2012, F12PGSQ5; F12PGSQ6; XIAYI COUNTY, 7 Sept. 2012, F12PGXY1.

Phylogenetic analysis

Of 1863 characters aligned with Clustal X and optimized manually to allow maximum alignment and maximum sequence similarity by BioEdit, 246 were parsimony informative. Ambiguously aligned regions were excluded from all analyses. The Kishino-Hasegawa (KH) test showed that three trees generated from parsimony analysis were retained. One of the most parsimonious trees is shown in FIG. 2 (TL = 867, CI = 0.9331, HI = 0.0669, RI = 0.8578, RC = 0.8005). MP and NJ bootstrap values are provided above branches. The phylogram in FIG. 2 illustrates that our isolate F11PGZH03 grouped with two *C. fruticicola* isolates in a single clade with 100%/100% bootstrap support, indicating that they may represent the same species.

In addition to isolating F11PGZH03, we isolated three strains of *C. fruticicola* in Henan Province in 2012. The grouping of these three strains was well supported by phylogenetic analysis of ITS sequences and multilocus sequence

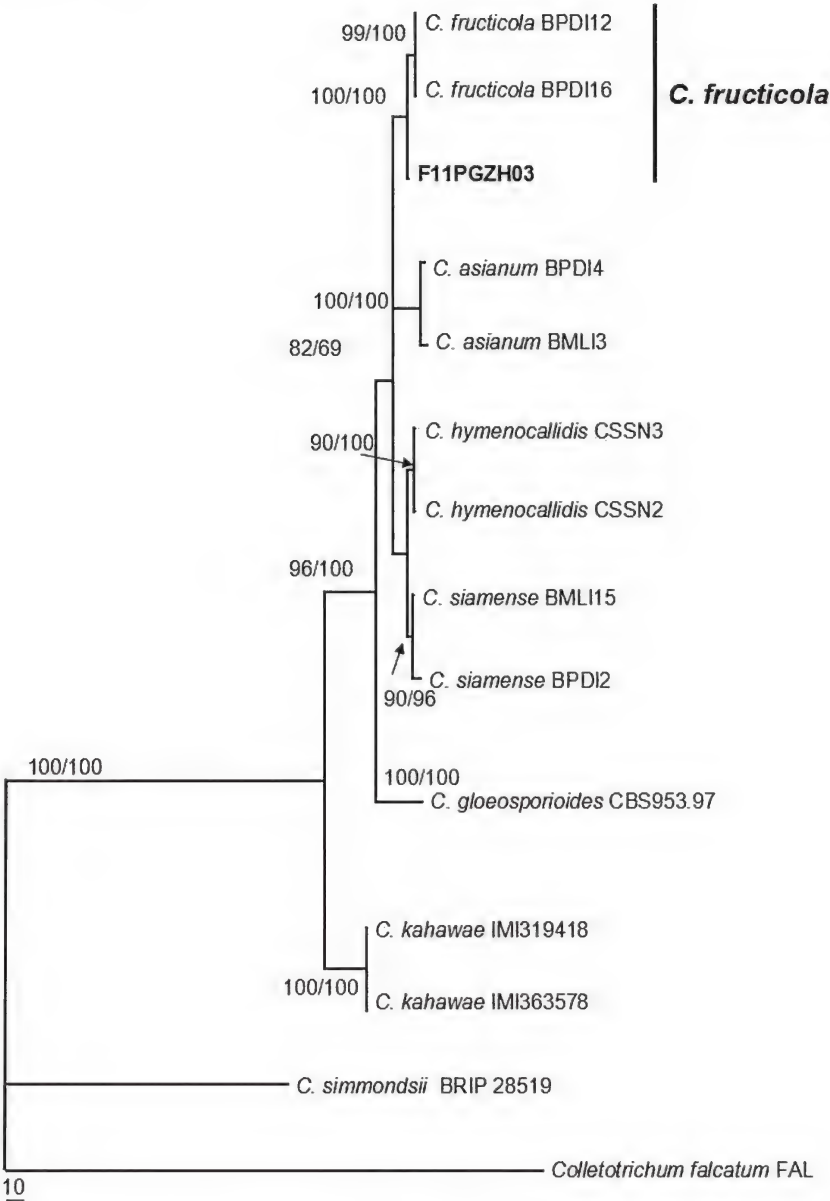


FIG. 2. Phylogram generated from maximum parsimony and neighbor-joining analyses based on combined ITS, ACT, TUB2, and GPDH sequence data. Clade stabilities shown above branches were calculated from maximum parsimony (>50%) and distance (>50%). The scale bar shows 10 changes. The tree is rooted with *Colletotrichum falcatum*.

data (results not shown). The colonies, conidia, and appressoria of our isolates were morphologically distinguishable from those of *C. gloeosporioides* complex.

Pathogenicity tests

All four isolates produced typical symptoms of bitter rot in Fuji apples by wound inoculation, except for isolate F11PGZH03, which did not produce rot symptoms after non-wound inoculation. Symptoms produced by each isolate were similar, and there were no apparent differences in lesion size and characters among isolates.

Discussion

Based on phylogenetic analysis of combined ITS/ACT/TUB2/GPDH datasets and morphological characters of the anamorph, we identified our isolates as *Colletotrichum fructicola*, which represent a new species record for the genus in China.

Colletotrichum fructicola was previously described only from coffee berries and leaf spots of peanut (Prihastuti et al. 2009). In this study we isolated the fungus from apple, which is a newly reported host for *C. fructicola*. Based on the pathogenicity test, *C. fructicola* was also determined to be a bitter rot pathogen of apple fruit.

Acknowledgments

This work was supported by National Natural Science Foundation of China (31171797), Program for Changjiang Scholars and Innovative Research Team in University (IRT0748), the 111 Project from Education Ministry of China (B07049) and Top Talent Project of Northwest A&F University. The authors wish to thank Dr Eric H.C. McKenzie (Landcare Research, Private Bag 92170, Auckland, New Zealand) and Professor Zhongyi Zhang (College of Plant Protection, Yunnan Agricultural University, Kunming, Yunnan, China) for reviewing the manuscript.

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MYCOTAXON

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***Phyllobaeis crustacea* sp. nov. from China**

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ABSTRACT — The lichen-forming fungus genus, *Phyllobaeis*, is reported for the first time from China. A new crustose species, *P. crustacea*, is described and illustrated.

KEY WORDS — *Ascomycota*, *Baeomycetaceae*, chemistry, molecular systematics, morphology

Introduction

The lichen-forming fungus genus *Phyllobaeis* is known from five squamulose species (Gierl & Kalb 1993, Index Fungorum 2013) occurring in the Neotropics. During our studies on the lichen flora of China we encountered a species that showed affinities with this genus but deviated conspicuously by its crustose (rather than squamulose) thallus. We present our analysis of the morphology, anatomy, chemistry, and phylogeny of this species to clarify its taxonomy.

Materials & methods

The material used in this study was collected from Hainan, Yunnan, and Qinghai provinces and Xizang (Tibet) autonomous region of China in 2010 and 2012, and from the Antarctica in 2011. The collections examined are preserved in the lichen section of the Herbarium Mycologicum Academiae Sinicae (HMAS-L). A specimen of *Phyllobaeis imbricata* was borrowed from the former Herbarium Universitatis Amstedamensis, now in Museum Naturalis in Leiden (L). A compound microscope (ZEISS Axioskop 2 plus) and a dissecting microscope (MOTIC SMZ-168) were used for the study of morphology and anatomy. A 10% solution of potassium hydroxide (KOH), a 5% bleaching solution (sodium hypochlorite, NaOCl), concentrated alcoholic *p*-phenylenediamine (PD), Lugol's solution of Iodine, and thin-layer chromatography (TLC) (Culberson & Kristinsson 1970; Culberson 1972; White & James 1985) were used for the detection of lichen substances.

TABLE 1. Twenty-two nrDNA ITS sequences used in phylogenetic analysis.

SPECIES	LOCALITY; VOUCHER SPECIMEN *	GENBANK NO. ^
<i>Baeomyces placophyllus</i>	Xizang, China; HMAS-L 124223	KC414621
	Xizang, China; HMAS-L 124222	KC414620
	China; —	DQ001274
<i>Baeomyces rufus</i>	Qinghai, China; HMAS-L 124225	KC414623
	Yunnan, China; HMAS-L 124226	KC414622
	France; —	AF448457
	France; —	AF448458
<i>Dibaeis absoluta</i>	Hainan, China; HMAS-L 118071	KC414625
	Hainan, China; HMAS-L 118073	KC414626
<i>Dibaeis baeomyces</i>	—	DQ782844
<i>Dibaeis soreliata</i>	Hainan, China; HMAS-L 118090	KC414627
	Hainan, China; HMAS-L 118097	KC414628
<i>Icmadophila japonica</i>	Japan; —	AB623070
<i>Phyllobaeis crustacea</i>	Hainan, China; HMAS-L 118086	KC414614
	Hainan, China; HMAS-L 118087	KC414615
	Hainan, China; HMAS-L 118089	KC414616
	Hainan, China; HMAS-L 118095 (holotype)	KC414617
	Hainan, China; HMAS-L 118096	KC414618
<i>Phyllobaeis imbricata</i>	Carchi, Ecuador; L 0790053	KC414619
	—	HQ650635
<i>Placopsis contortuplicata</i>	Antarctica; HMAS-L 124227	KC414624
	Antarctica; —	DQ534479

* Missing data indicated with “—”. ^ New sequences are shown in bold font.

DNA extraction, PCR amplification and sequencing

The extraction procedure followed the modified CTAB method (Wang et al. 2011). PCR amplifications were performed using a Biometra T-Gradient thermal cycler. The primer pair ITS5 and ITS4 (White et al. 1990) was used to amplify the nrDNA ITS region. Reactions were carried out in 50 µl reaction volume and the components used were 1 µl total DNA, 2 µl each primer (10 µM), 1 µl Taq polymerase (rTaq DNA Polymerase, 5 U/µl), 4 µl dNTP (2.5 mM each), 5 µl amplification buffer (10×, 25 mM MgCl₂ contained), 35 µl ddH₂O. Cycling parameters were set to an initial denaturation at 95°C for 5 min, followed by 30 cycles of denaturation at 94°C for 40 s, annealing at 52°C for 40 s, extension at 72°C for 2 min, and a final extension at 72°C for 10 min. Negative control, without DNA template, was prepared in every series of amplification in order to minimize the possibility of contamination. Finally, PCR products were purified by gel purification kit (Biocolor BioScience & Technology Co. Ltd.). Then, PCR products were sequenced using ABI 3730 XL DNA Sequencer.

Altogether 22 nrDNA ITS sequences belonging to nine species were used for the phylogenetic analysis (TABLE 1). Fifteen samples representing seven species were

sequenced by the authors, and another seven samples (belonging to six species) were downloaded from GenBank.

Phylogenetic analysis

All sequences were aligned using ClustalW 1.6 (Higgins et al. 1994). The phylogenetic analysis was executed with software Mega5.10 (Tamura et al. 2011). The Kimura-2-parameter was selected as the nucleotide substitution model, and gaps or missing data were set as pairwise deletion. The maximum likelihood (ML) method was used in constructing the phylogenetic tree and the reliability of the inferred tree was tested by 1000 bootstrap replications.

Results

The ML-tree (FIG. 1) of the ITS rDNA sequences shows that the five *Phyllobaeis crustacea* individuals cluster with 100% bootstrap support onto a separate branch, which is most closely related to *P. imbricata*. Together these two species form a common *Phyllobaeis* branch with 79% bootstrap support. *Baeomyces placophyllus* and *B. rufus* cluster together with 98% bootstrap support. *Phyllobaeis* and *Baeomyces* represent *Baeomycetaceae* with 59% bootstrap support. *Phyllobaeis* and *Baeomyces* represent *Baeomycetaceae* with 59%

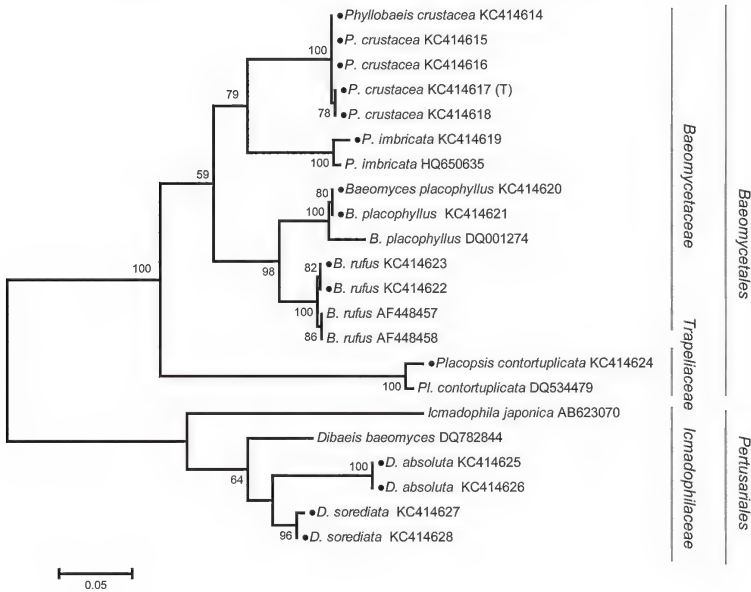


FIG. 1. ML tree based on nrDNA ITS region sequences. The species in the tree marked with “•” were sequenced by the authors. Nucleotide: K2 model, gaps or missing data were partial deletion, bootstrap = 1000. Genetic distance scale = 0.05. Numbers at nodes present the bootstrap support value (numbers <50 not shown).

bootstrap. Meanwhile, the *Baeomycetales*, containing the *Baeomycetaceae* and *Trapeliaceae* (represented by *Placopsis*), is supported by a bootstrap value of 100%, and the *Dibaeis* species (formerly included in *Baeomyces*) are clearly shown to belong to the outgroup, *Icmadophilaceae*.

Summarizing, the ITS rDNA sequences of *P. crustacea* differ significantly from the other species of *Baeomycetaceae* that are most closely related to the *Phyllobaeis* group.

Taxonomy

Phyllobaeis Kalb & Gierl, Herzogia 9:610.1993; emend. S.N. Cao & J.C. Wei

ORIGINAL DIAGNOSIS (Gierl & Kalb 1993: 610): *Genus novum a genere Baeomyces differt thallo squamuloso, superne et infra corticato acido norstictico continente; regionibus tropicis distributum.*

EMENDED DIAGNOSIS: Differs from *Baeomyces* by its production of norstictic acid and its tropical distribution.

Phyllobaeis crustacea S.N. Cao & J.C. Wei, **sp. nov.**

FIG. 2

FUNGAL NAME FN570052

Differs from the other *Phyllobaeis* species by its crustose thallus.

TYPE: CHINA, HAINAN: Changjiang County, Mt. Bawangling, 19°16' N 109°03' E, alt. 300 m, on rock, 25 Nov. 2010, S. N. Cao CSN047 (Holotype, HMAS-L 118095, GenBank KC414617; Isotype: HMAS-L 127984).

ETYMOLOGY: Latin *crustaceus*, referring to the crustose thallus.

THALLUS crustose, grayish green, matt, varnish-like, tightly attached to the substrate, forming a patch of 2.5–5 cm in diameter, lacking cortical layers, irregularly delimited; algae layer continuous, algal cells green, ovoid or ellipsoid, single, $5\text{--}7.5 \times 3.75\text{--}5\ \mu\text{m}$.

APOTHECIA pale reddish brown to brownish, round and plump, 0.3–0.5 mm in diameter, short-stiped, without clear margin, scattered over the thallus; podetia whitish, 0.1–0.5 mm tall, 0.5 mm in diameter, lacking algae; hymenium 112.5–125 μm thick, I–; paraphyses simple, non-septated; asci long-clavate, 8-spored, with apex I–, $80\text{--}87.5(92.5) \times 7.5\ \mu\text{m}$; ascospores oblong or fusiform, hyaline, one-septate, $10\text{--}12.5 \times 5\ \mu\text{m}$.

CHEMISTRY: Spot tests: Thallus K+ yellow turning red, C–, KC–, P+ yellow. All specimens contain norstictic acid (TLC).

ADDITIONAL MATERIAL EXAMINED: CHINA, HAINAN: CHANGJIANG COUNTY, Mt. Bawangling, 19°16' N 109°03' E, alt. 300 m, on rock, 25 November 2010, S.N. Cao CSN048 (HMAS-L 118096, GenBank KC414618); CSN049 (HMAS-L 118089, GenBank KC414616); CSN050 (HMAS-L 118087, GenBank KC414615); CSN051 (HMAS-L 118086, GenBank KC414614).

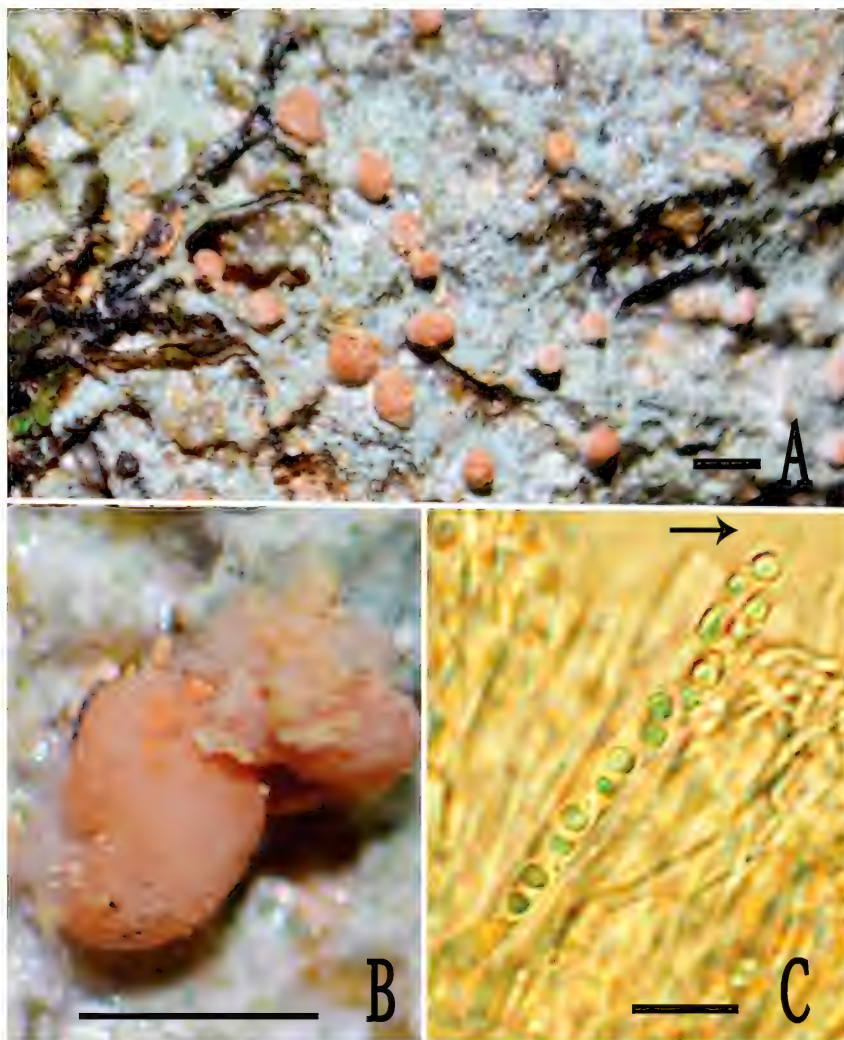


FIG. 2. *Phyllobaeis crustacea* (holotype): A, habit; B, apothecia; C, ascus with eight ascospores, apex I- (arrow). Scale bars: A, B = 0.5 mm; C = 10 μ m.

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a specimen on loan. Special thanks are due to Ms. H. Deng for giving considerable assistance during the studies in HMAS-L. This research was supported by the Ministry of Science and Technology of PRC (2006FY120100) and the Chinese Arctic and Antarctic Administration (2011GW12016).

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***Nipponoparmelia perplicata* sp. nov. (Parmeliaceae, Ascomycota)
from eastern Asia**

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ABSTRACT — A new species, *Nipponoparmelia perplicata* described from Korea and Russia, is segregated from *N. laevior*, from which it differs in having shorter and wider lobes that characteristically turn down towards the margins. The pseudocyphellae are inconspicuous, positioned along the lobe margins or on the underside. An improved description of *N. pseudolaevior* is presented, including new data on isidia with illustrations. A key to Korean *Nipponoparmelia* species is provided.

KEY WORDS — taxonomy, thallus morphology, distribution, ecology, secondary lobules

Introduction

The genus *Nipponoparmelia* (Kurok.) K.H. Moon et al. forms a separate main clade in the *Parmeliaceae* (Crespo et al. 2010), which includes a group of East Asian species previously placed in *Parmelia* Ach. s. str. According to Kurokawa (1994), who treated the group as a subgenus of three species within *Parmelia*, they differ morphologically from other *Parmelia* species by forming lateral punctiform pseudocyphellae. The pseudocyphellae resemble those of *Punctelia* Krog and *Flavopunctelia* (Krog) Hale in lacking a persistent epicortex roof and not forming angular or linear pore aggregates (Krog 1982; Hale 1984). However, in *Nipponoparmelia* the pseudocyphellae are marginal on lobes and lobules, not laminal as in *Punctelia* and *Flavopunctelia*. *Parmelia* subg. *Nipponoparmelia* Kurok. was recognized by a grey to grey-brown thallus with marginal punctiform pseudocyphellae and simple to furcate rhizines. Crespo

et al. (2010), who raised the subgenus to generic rank, included four species: *Nipponoparmelia isidioclada* (Vain.) K.H. Moon et al., *N. laevior* (Nyl.) K.H. Moon et al., *N. pseudolaevior*, and *N. ricasolioides* (Nyl.) A. Crespo & Divakar.

We have discovered a new *Nipponoparmelia* species, which we describe here as *N. perplicata*. We also present an improved description of *N. pseudolaevior* and provide a key to Korean *Nipponoparmelia* species.

Taxonomy

Nipponoparmelia perplicata S.Y. Kondr., Tschab., Elix & Hur, **sp. nov.** Figs 1, 2

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Differs from *Nipponoparmelia laevior* by its smaller thalline lobes, helmet-shaped marginal lobes, larger and mainly inconspicuous pseudocyphellae on the upper side, and wider ascospores.

TYPE — South Korea: Mt. Jiri, 35°19'30.0"N 127°42'45.7"E, 1755 m, on bark of *Malus baccata* (L.) Borkh. (*Rosaceae*), 23.iv.2004, J.-S. Hur 040372 (**Holotype**, KoLRI 001148).

ETYMOLOGY — The species epithet refers to the inconspicuous pseudocyphellae.

Thallus 5–8(–10) cm broad, adnate to loosely adnate, dark greenish, olive-grey to whitish mineral gray; lobes to 4(–7) mm long and 1–2(–3) mm wide, subirregular, somewhat subconvex to convex due to the downwards folded edges, contiguous to subimbricate, non-ascending and non-sinuate, without isidia and soredia, upper surface matt to shiny, rarely foveolate, upper surface mainly entire even on older lobes, pseudocyphellae from punctiform and rounded or elongate to fissure-like to 0.6–1(–1.5) mm in diam., usually inconspicuous, usually marginal but rarely laminal on the underside; medulla white; lower surface black, often with pale or dark brownish marginal zone, moderately to densely rhizinate, the rhizines simple or furcate.

Apothecia sometimes abundant, more or less stipitate, 2–7 mm in diameter, thalline margin more or less foveolate, pseudocyphellae punctiform, highly elevated, pseudocyphellae often present on the inner side of the thalline margin, disc brown, reddish brown to dark brown. Ascospores (10–)13–17 × (7–)8–11(–12) µm.

CHEMISTRY — Thallus K+ yellow becoming brownish, C–, Pd+ yellow; medullar K+ yellow becoming red, C–, Pd+ deep yellow, slowly becoming orange. Atranorin, chloroatranorin, salazinic acid, and traces of consalazinic and protocetraric acid.

ECOLOGY & DISTRIBUTION — On trunk or twigs of trees. Known from scattered localities in South Korea and far eastern Russia.

OTHER SPECIMENS EXAMINED — SOUTH KOREA: JEOLLANAM-DO, Gurye-gun, Jiri Mt., 35°17'49.5"N 127°33'36.2"E, 1281 m, on bark of *Quercus*, 27.ix.2006, J.-S. Hur 20060783 (KoLRI 005162); Mt. Jiri, 35°18'56.0"N 127°41'29.7"E, 1690 m, on bark of *Quercus*, 23.iv.2004, J.-S. Hur 040354 (KoLRI 001130); KANGWON-DO, Shokcho city,

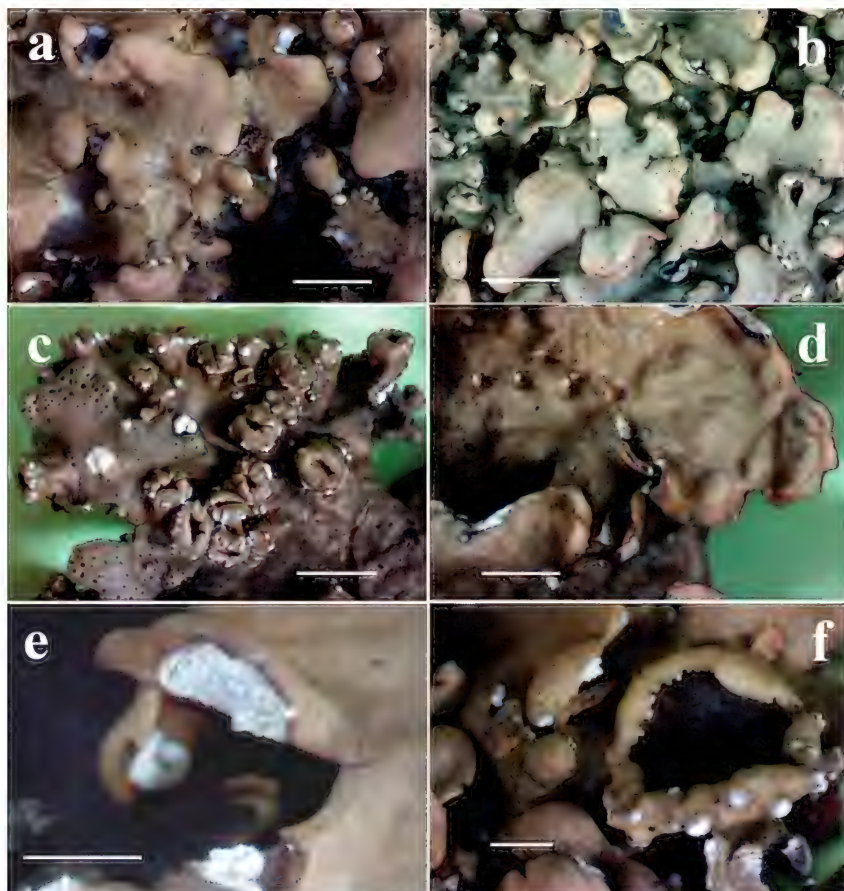


FIG. 1. *Nipponoparmelia perplicata*: general habit. Scale bars: a–d = 2 mm; e–f = 1 mm.

Seorak-dong, Mt. Sorak, 38°09'47.3"N 128°27'32.2"E, 810 m, on bark, 17.vi.2005, J.-S. Hur 050284 (KoLRI 003188); JEOLLABUK-DO, Jeongup-si, Mt. Naejang, 35°28'57.8"N 126°52'59.6"E, 711 m, on bark of *Quercus*, 8.viii.2003, J.-S. Hur 030621 (KoLRI 000428); GYEONGSANGNAM-DO, Hapcheon-gun, Gaya-myeon, Mt. Gaya, 35°49'05.6"N 128°07'33.2"E, 1340 m, on twigs of *Rhododendron*, 5.v.2006, J.-S. Hur 20060152 (KoLRI 004524); GANGWON-DO, Seon-gun, Gohan-eup, Mt. Hambae, 37°11'47.4"N 128°54'53.6"E, 1355 m, on bark of *Quercus*, 19.vi.2007, J.-S. Hur 070652 (KoLRI 007511), Mt. Hambae, 37°11'43.0"N 128°54'51.6"E, 1403 m, on bark of *Quercus*, 19.vi.2007, J.-S. Hur 070661 (KoLRI 007534); [Mt. Suk Byeng], 37°34'29.9"N 128°51'21.8"E, 686 m, on bark, growing together with *Flavoparmelia caperata*, 24.v.2008, J.-S. Hur 080187 (KoLRI 008433, sub *Flavoparmelia caperata*); Mt. Deogyo, 35°51'15.8"N 127°44'55.2"E, 1601 m, on bark of *Quercus*, growing together with *Biatora* sp., 10.viii.2006, J.-S. Hur 20060457 (KoLRI 004825). RUSSIA: SHIKOTAN ISLAND, near mountain Notoro, on

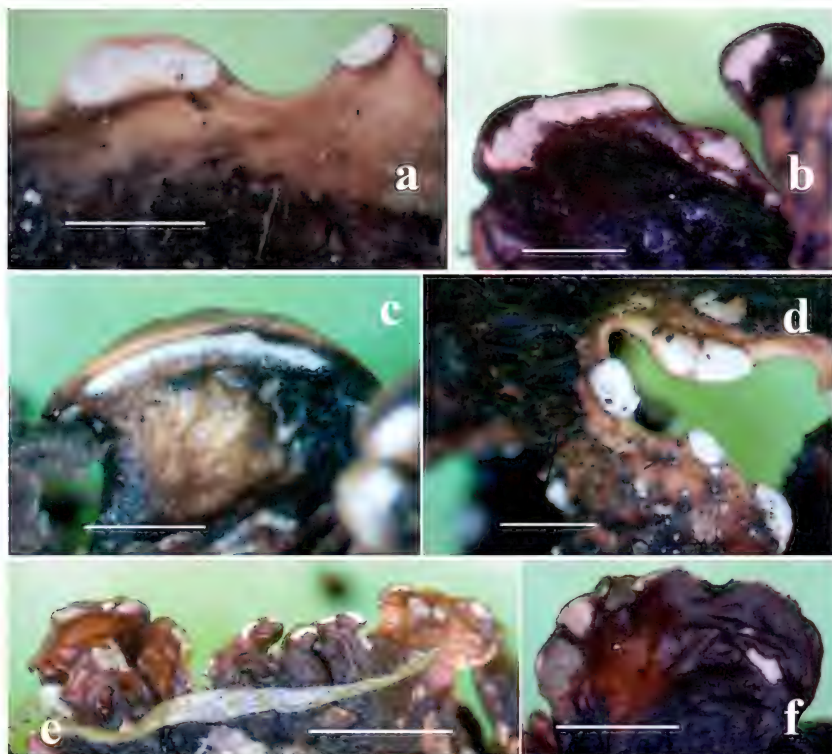


FIG. 2. *Nipponoparmelia perplicata*: general view of pseudocyphellae on underside. Scale bars: a–d, f = 1 mm; e = 2 mm.

Betula ermanii, 43°47'21.1"N 146°42'26.7"E, 229 m alt., 14.viii.2010, S. Tschabanenko (SAKH).

TAXONOMIC NOTES — *Nipponoparmelia perplicata* is distinguished from the four other *Nipponoparmelia* species by the irregular lobes with the characteristically down-turned lobe ends that produce a helmet-shaped impression. The pseudocyphellae of *N. perplicata* are inconspicuous, seen mainly on the underside where they are marginally (rarely laminally) positioned, and the lack of marginal lobules and isidia.

Nipponoparmelia isidioclada is densely supplied with branched cylindrical, slightly dorsiventral, eventually 1 mm high coralloid–isidioid structures. It further differs from *N. perplicata* by smaller pseudocyphellae and presence of gyrophoric and 4-*O*-methylgyrophoric acids (Park 1990; Kurokawa 1994).

Nipponoparmelia laevior, one of the commonest lichens in montane and subalpine areas in Japan and Korea, is characterized by marginal punctiform pseudocyphellae, a shiny and smooth upper surface, and simple to furcate

rhizines and sublinear lobes with distinctly ascending edges. Furthermore, the ascospores of *N. laevior* are $12\text{--}16 \times 6\text{--}9 \mu\text{m}$, slightly narrower than those of *N. perplicata* (Park 1990; Kurokawa 1994).

Nipponoparmelia pseudolaevior differs from *N. perplicata* by numerous subascending to suberect isidia along the margin and on the surface of the lobes (Park 1990; Kurokawa 1994).

Similar to *N. perplicata*, *Cetreliaopsis asahinae* (M. Satō) Randlane & A. Thell possesses pseudocyphellae on the underside. However, *C. asahinae* also produces conspicuous pseudocyphellae on the upperside (Randlane & Thell 1995). The lobes of *N. perplicata* are smaller and much more closely attached and the lower surface is smoother. Furthermore, *C. asahinae* is usually supplied with marginal apothecia and the secondary chemistry is characterized by fumarprotocetraric acid.

Nipponoparmelia pseudolaevior (Asahina) K.H. Moon, Y. Ohmura & Kashiw.,
in Crespo et al., Taxon 59(6): 1749 (2010).

FIG. 3

Thallus to 10 cm across, adnate or subadnate, dull brownish or dull greenish grey; lobes subirregular, continuous or more or less divaricate, 1–3 mm wide, with more or less ascending margins, upper surface shiny and smooth towards the tips and matt and somewhat wrinkled in the centre, usually with numerous laminal secondary lobules and numerous finger like to cylindrical isidia in the centre of thallus; rarely secondary lobules and isidia with white pruinae in places, pseudocyphellae rather small and inconspicuous, 0.1–0.2(–0.3) mm in diam./across, mainly along the margins, sometimes becoming isidiate (not becoming granular and not giving rise to coralloid-isidioid growths). Secondary lobules 1–2.5(–3) mm wide/across, from rounded to irregular, with distinctly attenuated basis, laminal. Isidia 0.7–1.5(–2) mm long, finger-like to cylindrical, 0.1–0.3 mm wide, scarcely branched, usually numerous along the edges of the main lobes and the edges of the secondary lobules, especially abundant in the centre of the thallus (not being apically crumbling and subsorediate with age). Upper surface shiny, pruinose in parts, plane to slightly wrinkled, lobe edges pseudocyphellate; pores more or less punctuate. Medulla white. Lower surface black, often with a pale of brownish narrow peripheral zone, moderately to densely rhizinate, the rhizines simple or furcated, to 1.5(–2) mm long. Apothecia rare, more or less stipitate, 1–8(–11) mm diam., dentate or lobate along the margin, amphithecium smooth, pseudocyphellate, pseudocyphellae punctuate, more or less elevated, disc buff brown, radially split with age, spores $10\text{--}12 \times 15\text{--}17 \mu\text{m}$. Pycnidia common, submarginal.

CHEMISTRY — Thallus K+ yellow, C–, KC–, P+ yellow; medulla K+ yellow, becoming red or brown, C–, P+ deep yellow, than slowly becoming orange. Atranorin, chloratranorin, and salazinic acid; consalazinic acid, a fatty acid and protocetraric acid as accessories.



FIG. 3. *Nipponoparmelia pseudolaevior*: A. general habit; B. central portion of thallus; C. lobe; D, laminar lobules; E–F. isidia. Scale bars: A, B = 2 mm; C–F = 1 mm.

SPECIMENS EXAMINED — SOUTH KOREA: Mt. Taebaek, 1016 m alt, on rock, 2.xi.2003, J.-S. Hur 030888 (KoLRI 000678); Mt. Baegun, 1105 m alt, 5.v.2003, J.-S. Hur 030188 (KoLRI 000143). RUSSIA: SAKHALIN ISLAND, Kholmsky district, Slepikovsky cape, 47°17'59.33"N 141°59'37.7"E, mix forest (*Abies* + *Quercus* + *Sorbus*), on *Quercus crispula*, 2006, S. Tschabanenko (SAKH); Uglegorsky district, Bolshoi Nadym River, 49°00'54.06"N 142°15'13.01"E, mix forest, on *Sorbus commixta*, 2003, S. Tschabanenko (SAKH); SHIKOTAN ISLAND, 43°47'21.1"N 146°42'26.7"E, mix forest, Gorobets River, on *Alnus hirsuta*, 14.viii.2010, S. Tschabanenko (SAKH); ITURUP ISLAND, near Lesozavodskoye, mix forest, on *Padus ssiuri* [date and collector unrecorded] (SAKH); PRYMORSKY KRAI, Lazovsky district, valley Proselochnaya River, 43°00'48.81"N 134°07'00.58"E, deciduous–coniferous forest, on *Quercus mongolica* and *Alnus japonica*, 1985, S. Tschabanenko (SAKH); Lazovsky district, valley Valunovka River, 43°08'45.37"N 133°48'25.75"E, deciduous–coniferous forest, on *Quercus mongolica*, 1986, S. Tschabanenko (SAKH); Lazovsky district, *Quercus* forest near maritime coast

(Zapovednoye village), 42°50'25.74"N 133°42'02.6"E, on *Quercus mongolica* and *Q. dentata*, 1985, S. Tschabanenko (SAKH); Lazovsky district, *Quercus* forest near maritime coast Krasnyi Olenovod, 42°52'19.1"N 133°46'51.46"E, on *Quercus mongolica* and *Q. dentata*, 1985, S. Tschabanenko (SAKH); Ussurijsky district, Zharikov Stream, deciduous–coniferous forest, on *Alnus hirsuta*, [date unrecorded] S. Skirina (SAKH); Khasansky district, valley Kedrovaya River, 43°06'10.64"N 131°31'48.75"E deciduous–deciduous forest, on *Quercus mongolica*, [date unmentioned], S. Skirina (SAKH); **KHABAROVSKY KRAI**, valley Gorin River, mix forest, on *Quercus mongolica*, [date unrecorded], A. Mikulin (SAKH).

ECOLOGY & DISTRIBUTION— On bark of *Cryptomeria japonica* and various deciduous trees, rarely on *Tsuga diversifolia*, *Abies veitchii*, and *A. sachalinensis* and on rocks, growing sometimes together with *Menegazzia subsimilis* and *Parmelia* and *Lepraria* species. Known from eastern Asia (Japan, South Korea, far eastern Russia). Known in South Korea only from two localities, Mt. Taebaek and Mt. Baegun.

TAXONOMIC NOTES — *Nipponoparmelia pseudolaevior* is closely related to *N. laevior*, from which it is clearly distinguished by the numerous subascending to suberect isidia formed on the margin and less commonly present on the surface of lobes. It is apparently the isidiate morphotype of *N. laevior*, which has a similar distribution range in eastern Asia.

Nipponoparmelia pseudolaevior differs from *N. isidioclada*, a mainly epiphytic species known from Russian Far East, Japan, and Taiwan, by presence of secondary lobules and larger pseudocyphellae, longer isidia, and absence of gyrophoric acid.

Some Korean specimens of *N. pseudolaevior* were previously misidentified as *Punctelia rudecta* (Ach.) Krog, from which it differs in having only marginal punctiform pseudocyphellae, laminal secondary lobes with numerous marginal isidia and a black underside.

In contrast to Russian literature (Rassadina 1971), true isidia were not mentioned for *N. pseudolaevior* in Korean and Japanese keys, being categorized as secondary lobules (Park 1993; Kurokava 1994). However, isidiate material from South Korea and Russia does represent *N. pseudolaevior*.

Key to Eastern Asian *Nipponoparmelia* species

1. Thallus isidiate, with coralloid-isidioid growths or with dense suberect, marginal cylindrical isidia 2
1. Isidia absent. 3
2. Isidia apically crumbling and subsorediate; pseudocyphellae becoming granular-isidiate and giving rise to coralloid-isidioid growths to 1 mm high *Nipponoparmelia isidioclada*
2. Isidia not sorediate, regularly cylindrical, dense and suberect along edges of lobules. *Nipponoparmelia pseudolaevior*

3. Lobes sublinear, with ascending margins; pseudocyphellae well distinct, conspicuous from upper surface. *Nipponoparmelia laevior*
3. Lobes irregular, margin folded downwards; pseudocyphellae indistinct, better seen from underside *Nipponoparmelia perplicata*

The status of *N. laevior* specimens with secondary lobules but without isidia will be investigated in the future.

Acknowledgements

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***Buelliella*, *Codonmyces*, and *Polycoccum* species new to Turkey**KENAN YAZICI^{*1} & JAVIER ETAYO²¹*Biology Department, Faculty of Science, Karadeniz Technical University, 61080, Trabzon, Turkey*²*Navarro Villoslada 16, 3^o dcha, 31003 Pamplona, Navarra, Spain*^{*}CORRESPONDENCE TO kcagri_1997@yahoo.com

ABSTRACT — Three species of lichenicolous fungi are reported as new to Turkey: *Buelliella poetschii* and *Codonmyces lecanorae* (both also new to Asia) and *Polycoccum pulvinatum*. Short descriptions are presented, including geographic distribution, host, and a comparison with similar taxa.

KEY WORDS — *Ascomycetes*, biodiversity, coelomycetes, Burdur, *Dothideales*

Introduction

Although studies on the lichenicolous fungi of Turkey are insufficient and not intensive, there have been an increasing number of publications on the subject during 2009–11 (Candan & Halici 2009, 2011, Etayo & Yazici 2009, Halici et al. 2010a,b, Yazici et al. 2010, 2011). Recently, during our study of the lichens and bryophytes of Burdur Province, we identified some lichenicolous fungi. Although 139 taxa of lichenicolous fungi are known from other regions of Turkey (Yazici et al. 2011), no lichenicolous fungi have been reported from Burdur.

This number is small when compared with other European countries (Fałtynowicz 2003, Hawksworth 2003, Kocourková 2000, Santesson 1993, Scholz 2000). Thus exploration of more regions of Turkey is urgently needed.

Materials & methods

The present report is based on collections from the Burdur region made on 25 and 29 June 2012. Burdur has a continental Mediterranean climate with cold, snowy winters and very hot, long and dry summers. The temperature ranges from –16 to 39°C with a mean of 15°C; the annual rainfall averages 468 mm, and the average humidity is 51.2% (Akman 1999).

The visited areas (Bucak and Altınyayla districts) are mountainous with vast forested areas dominated by *Abies*, *Cedrus*, *Ficus*, *Fraxinus*, *Juniperus*, *Olea*, *Pinus*, *Pistacia*, *Prunus*, *Quercus* (especially in Altınyayla district), and *Rhus*, and alternating streams,

lakes, and dams (e.g., Yapraklı Dam in Altınyayla district, and Karacaören dam in Bucak district) (Baytop & Denizci 1963). Within the forests, other flora is very abundant, and marble rock is common.

Hand-cut sections were examined microscopically in water (including all measurements), 10% KOH, and lactophenol cotton blue. Air-dried samples were observed using a Nikon SMZ1500 stereomicroscope and a Nikon Eclipse 80i light microscope. Nomenclature and species concepts follow Hawksworth & Diederich 1988, Pegler et al. 1980, Hafellner et al. 2008, Calatayud & Etayo 1999, and Etayo 2010a. Vouchers are stored in the herbarium of the Biology Department, Faculty of Science, Karadeniz Technical University, Trabzon, Turkey (KTUB). The descriptions are based on Turkish specimens.

The species

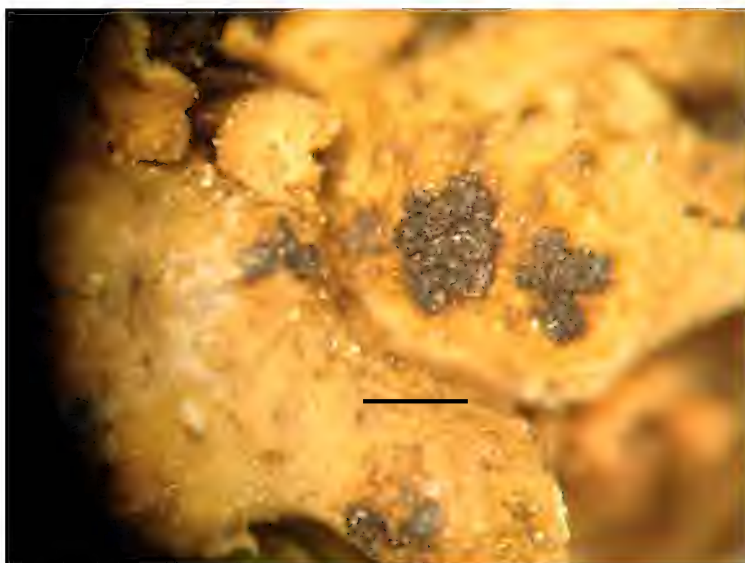


FIG. 1. *Buelliella poetschii*, habitus with apothecioid ascomata. Scale = 1mm

Buelliella poetschii Hafellner, Mitt. Naturw. Ver. Steierm. 137: 187. 2008

FIG. 1

Detailed descriptions: Hafellner et al. (2008); Etayo (2010a).

Ascomata apothecioid, dispersed over the host thallus in black spots with 1–4 tiny composite groups of apothecia, rarely single, rounded, globular when young, pressed at the edges, later oval, up to 120–1200 μm in diam., often bleaching the host thallus, occasionally sunken. Vegetative hyphae intercellular. Hymenium hyaline to brownish, on the outside olive-brown, c. 60–70 μm high, I–, KI–. Excipulum dark brown, K+ greenish-brown. Paraphyses branched, anastomosing, capitate at apical and intercalary cells with pigment, cells at tips 4–5 μm thick with dark-brown pigment. Asci cylindrical, fissitunicate,

4–6-spored. Ascospores, long, hyaline, later $\pm$ brown, thin walled, 1-septate, clearly constricted at the septa, cells rounded, the upper one sometimes tapered, (15–)16–16.3–18.5(–20) $\times$ 6.5–7.2–8.5 μm (n = 15).

SPECIMEN EXAMINED: **TURKEY. BURDUR:** BUCAK, surroundings of Karacaören Dam, 37°21'35.14"N 30°50'05.80"E, 300 m, on the thallus of *Endocarpon* sp., 25.06.2012, leg. K.Yazici (KTUB–2353).

Our specimen was found on an *Endocarpon* thallus, which appeared damaged by this fungus. *Buelliella poetschii* has previously been found growing on the thalli of *Endocarpon* and *Catapyrenium* species (*E. adscendens*, *E. adsurgens*, *E. loscosii*, *E. pusillum* agg., *Catapyrenium* sp.) on exposed calcareous rocks.

The species was previously known from Europe, North America, and South America (Hafellner et al. 2008, Diederich et al. 2009, Etayo 2010a,b, Urbanavichus & Urbanavichene 2011, Flakus & Kukwa 2012). New to Turkey and Asia.

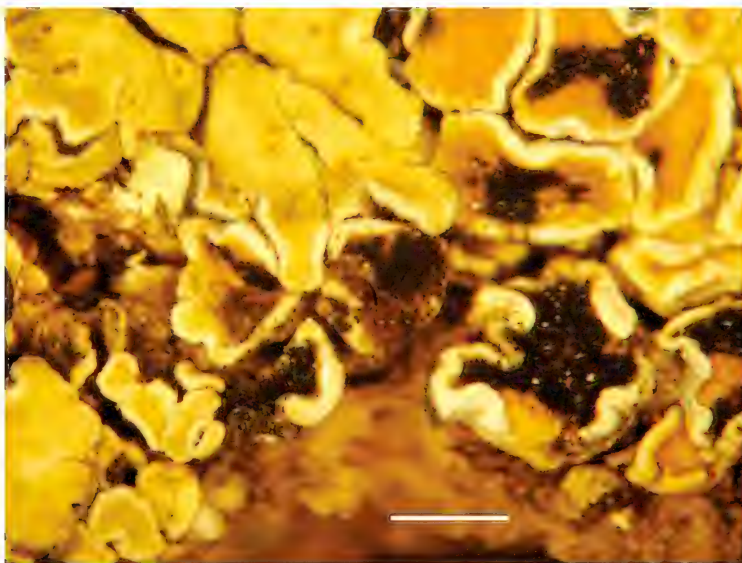


FIG. 2. *Codonmyces lecanorae*, habitus with apothecia. Scale = 1mm

Codonmyces lecanorae Calat. & Etayo, Lichenologist 31(6): 594. 1999

FIG. 2

Detailed description: Calatayud & Etayo (1999).

Vegetative hyphae spanning fully or partly the apothecia and thallus of the host lichen. Conidiophores $\pm$ cylindrical, hyaline, and immersed in the host tissue, up to 3–4 μm wide. Cells near the surface of the host tissue $\pm$ globular and 6–7 μm wide, colourless or $\pm$ pale brown. Conidiogenous cells formed by a globose cell with annellations, globose cells with $\pm$ smooth and $\pm$ dark brown surfaces, annellations $\pm$ dark brown, (8–)9–11(–12) $\times$ (4–)5–8(–9) μm

(including the annellations). Conidia 1-septate, brown, oblong with rounded apices, constricted at the septum, $(6-7-11(-12) \times (4-5-6 \mu\text{m})$ ($n = 20$).

SPECIMEN EXAMINED: TURKEY. BURDUR: ALTINYAYLA, between İbecik-Altinyayla road, $36^{\circ}56'59.32''\text{N}$ $29^{\circ}27'40.68''\text{E}$, 1373 m, on the thallus and apothecia of *Protoparmeliopsis muralis*, 29.06.2012, leg. K.Yazıcı (KTUB-2345).

Our specimen growing on the apothecia and thallus of *Protoparmeliopsis muralis* was not deformed in the affected parts, although the host was moderately damaged. *Codonmyces lecanorae*, previously known from Europe, is new to Turkey and Asia.

REMARKS — *Codonmyces* is similar to *Xanthoriicola* (Hawksworth & Punithalingam 1973, Hawksworth, 1979) in producing effuse powdery colonies lacking stromatic structures and sporodochia. The morphologically similar *Xanthoriicola physciae* is distinguished by simple conidia that are not 1-septate. Additionally warts in *Xanthoriicola* are typically spinulose (Hawksworth 1979, Ellis 1976), and not flattened as in *Codonmyces* (Calatayud & Etayo 1999).



FIG. 3. *Polycoccum pulvinatum*, habitus with galls, including perithecioid ascomata.
Scale = 1mm

Polycoccum pulvinatum (Eitner) R. Sant., Lich. Lichenic. Fungi Sweden Norway:
175. 1993

FIG. 3

Detailed description: Hawksworth (1975).

Galls wart-like, on *Physcia* sp., convex or hemispherical, 1–2.5 mm in diam., ascomata perithecioid (pseudothecium), $150-290 \times 140-200 \mu\text{m}$, subglobose, arising singly, walls of angular pseudoparenchymatous cells, hymenium

not exposed at maturity; hamathecium of branched and anastomosing pseudoparaphyses. Asci 60–80 × 14–18 µm, cylindrical-clavate, (4–)8-spored; ascospores 1-septate, 14–20 × 6–8(–9) µm (n = 18), ellipsoid to oblong-ellipsoid, brown at maturity, perispore present.

SPECIMEN EXAMINED: TURKEY. BURDUR: ALTINYAYLA, between İbecik-Altınyayla road, 36°56'59.32"N 29°27'40.68"E, 1373 m, on the thallus of *Physcia* sp., 29.06.2012, leg. K. Yazıcı (KTUB–2352).

Widespread in Mediterranean to boreal and arctic-alpine areas, *P. pulvinatum* induces the gall formation and grows on *Physcia* spp. (e.g., *P. adscendens*, *P. caesia*, *P. dubia*, *P. tenella*). The species is known from all continents except Africa and is widely distributed in Europe (Alstrup et al. 2009, Hawksworth 1983, Pegler et al. 1980). New to Turkey.

REMARKS—*Polycoccum pulvinatum* resembles *P. clauzadei*, which differs in its smaller galls and ascomata. Additionally, its ellipsoid or oblong-ellipsoid ascospores and usually 8-spored asci distinguish *P. pulvinatum* from *P. clauzadei* with obovoid or soleiform ascospores and 4–6-spored asci (Navarro-Rosinés & Roux 1998).

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MYCOTAXON

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***Passalora lepestemonis* sp. nov. from China**LEI XIA¹, YING-LAN GUO² & YU LI¹ *¹ Engineering Research Center, Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, 2888 Xincheng Street, Changchun City, P.R. China² State Key Laboratory of Mycology, Institute of Microbiology Chinese Academy of Sciences, Beijing 100101, P.R. China* CORRESPONDENCE TO: yuli966@126.com

ABSTRACT — A new species of *Passalora*, *P. lepestemoni*, is described and illustrated. The type specimen is deposited in HMAS.

KEY WORDS — taxonomy, microfungi, anamorphic fungi, tropical fungi, plant pathogen

Introduction

More than 600 species have been reported from *Passalora* (teleomorph *Mycosphaerella*) (Kirk et al. 2008), a hyphomycete genus established by Fries in 1849. *Passalora* species are common parasites of a large number of plants, often causing spots on leaves, stems, flowers, fruits, and seeds resulting in serious economic damage due to decreased plant production. The primary morphological generic characters include pale olivaceous to almost black stromata (when present); solitary to fasciculate pale olivaceous to dark brown conidiophores; obvious conidial scars; solitary conidia that are variably shaped (straight to curved, cylindrical, clavate, fusiform), hyaline to dark olivaceous brown, nonseptate to multiseptate, and with an obvious hilum.

The authors found a new species from diseased leaves of *Lepistemon binectariferum*, collected in Hainan Province, China. The species is described and illustrated here.

Taxonomy***Passalora lepestemonis* L. Xia, Y.L. Guo & Yu Li, sp. nov.**

FIG. 1

MYCOBANK MB802399

Differs from other *Passalora* species reported on convolvulaceous hosts by its paler and shorter conidiophores, its conidial size and shape, and its lack of stromata.

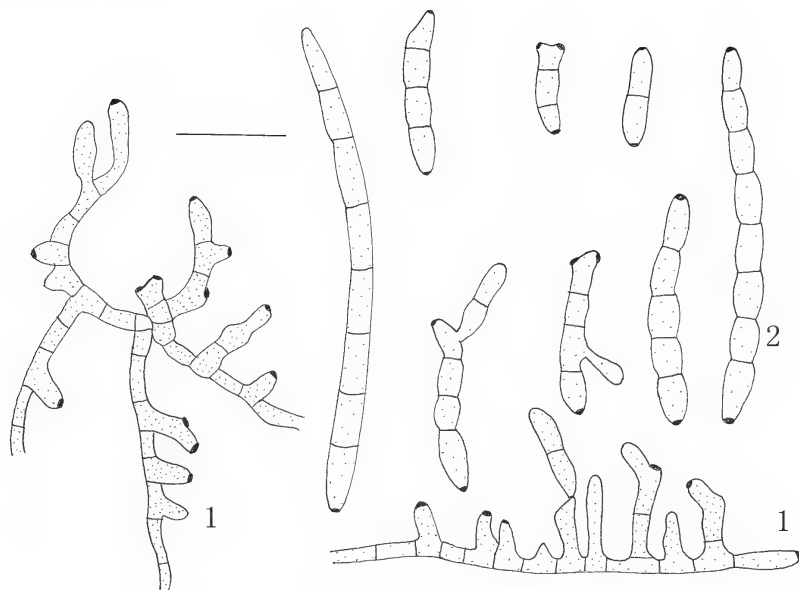


FIG. 1. *Passalora lepistemonis* (HMAS 244085, holotype).
1. Conidiophores; 2. Conidia. Bar = 25 µm.

TYPE—China, Hainan Province, Bawangling, from leafspots on *Lepistemon binectariferum* (Wall.) Kuntze (Convolvulaceae), 11 XII 2009, coll. Guo Ying-lan, (Holotype HMAS 244085).

ETYMOLOGY: Named after the host genus *Lepistemon*.

LEAF spots amphigenous, angular, without definite margin, vein-limited, 1.5–5 mm wide, often confluent, at first pale green, later pale to medium yellowish brown on the upper surface, laurel-green to pale yellowish brown on the lower surface. CAESPITULI hypophyllous, effuse. PRIMARY mycelium internal; secondary mycelium external, hyphae pale olivaceous to olivaceous, branched, septate, smooth, 2–2.5 µm wide. STROMATA absent. CONIDIOPHORES emerging through the stomata, acrogenous or as lateral branches singly arising from the external mycelia, olivaceous to very pale olivaceous brown, uniform in color, irregular in width, wider on the base, straight to slightly curved, unbranched, 0–1geniculate, broadly obtuse to conical at the apex, usually not septate, 2.5–10.5 × 4–5.3 µm, sometimes longer conidiophores 1-septate, up to 25 µm in length. CONIDIAL scars conspicuously thickened, 1.5–2.8 µm wide. CONIDIA cylindrical or sometimes obclavate for shorter ones, olivaceous to very pale olivaceous brown, catenulate and in branched chains, straight to curved, conical or broad-round to truncate at the apex, obconically truncate at the base,

shorter conidia 0–2-septate, longer conidia 3–7-septate, constricted at septa, $25\text{--}110 \times 4\text{--}6.7\text{ }\mu\text{m}$.

Discussion

More than ten species have been reported on plants of *Convolvulaceae*, of which five were similar to *Passalora lepidemonis* in producing ceratoid and inconspicuous or irregular leaf spots, and effused hypophyllous caespituli: *P. balansae* (Speg.) U. Braun on *Evolvulus* sp.; *P. convolvuli* (Tracy & Earle) U. Braun & Crous on *Convolvulus acetosifolia*, *C. arvensis*, and *Ipomoea* sp.; *P. lettsomiae* (Thurum. & Chupp) Crous & U. Braun on *Argyrea* spp.; *P. merremiae* (X.J. Liu & Y.L. Guo) U. Braun & Crous on *Merremia umbellata* subsp. *orientalis*; and *P. turbinae* (Chupp) U. Braun & Crous on *Ipomoea burmannii* and *Turbina corymbosa* (Braun 2000; Crous & Braun 2001, 2003).

Passalora balansae produces darker (medium brown) longer (50–300 μm) conidiophores and paler (very pale olivaceous) shorter and wider (25.6–60 $\times$ 5–8 μm) conidia (Braun 2000).

Passalora convolvuli has stromata (brown to almost black, 20–50 μm diam), densely fasciculate, darker (pale to medium olivaceous brown), longer (10–50 μm) conidiophores, and paler (hyaline to subhyaline), obclavate-cylindrical, narrower (3–4 μm) conidia (Crous & Braun 2003).

Passalora lettsomiae produces darker (fuliginous to almost black) angular leaf spots, fasciculate (5–20) conidiophores, and cylindrical-obclavate narrower (3–4.5 μm) conidia (Crous & Braun 2001).

Passalora merremiae has darker (pale brown), wider (5.5–10 μm diam), catenulate conidia, and darker (pale brown to brown) larger (12.5–108 $\times$ 5–8.8 μm) conidiophores (Crous & Braun 2003).

Passalora turbinae produces small (25 μm diam) reddish brown stromata, densely clustered longer (15–55 μm) paler 0–4 septate conidiophores, and smaller (15–60 $\times$ 3–5 μm) conidia (Crous & Braun 2003).

All these species differ from the fungus found on *Lepistemon binectariferum*, described and illustrated above as a new species.

Acknowledgments

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Two new species of *Spadicoides* from southern China

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ABSTRACT — *Spadicoides bawanglingensis* sp. nov. and *S. longchiensis* sp. nov. are described and illustrated from plant debris in natural areas of southern China. The type specimens are deposited in HSAUP (Herbarium of Department of Plant Pathology, Shandong Agricultural University) and HMAS (Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences).

KEY WORDS — anamorphic fungi, taxonomy

Introduction

Spadicoides was established by Hughes (1958) with *S. bina* (Corda) S. Hughes as the type species. The genus is characterized by distinct, single, erect, straight or flexuous, branched or unbranched conidiophores with polytretic, terminal or intercalary conidiogenous cells that produce solitary, acropleurogenous, euseptate, variously shaped conidia (Ellis 1971, Kuthubutheen & Nawawi 1991). Thirty-four species have been accepted in *Spadicoides* (Mycobank 2013), seven of which have been described from China (Zhou et al. 1999, Wong et al. 2002, Ho et al. 2002, Cai et al. 2004, Li et al. 2010, Ma et al. 2010, 2012a).

Fungal diversity in China is high but still mostly unexplored. We have previously described several new species from Hainan and Sichuan Province (Zhang et al. 2009, Ma et al. 2012b,c, Ren et al. 2012). During our ongoing survey of anamorphic fungi associated with plant debris in tropical and subtropical forests of southern China, two new species with morphological characteristics of *Spadicoides* were collected on dead stems.

***Spadicoides bawanglingensis* J.W. Xia & X.G. Zhang, sp. nov.**

FIG. 1

MYCOBANK MB 807061

Differs from all other *Spadicoides* species with obclavate conidia by its larger conidia with a long rostrum (beak or apical prolongation).

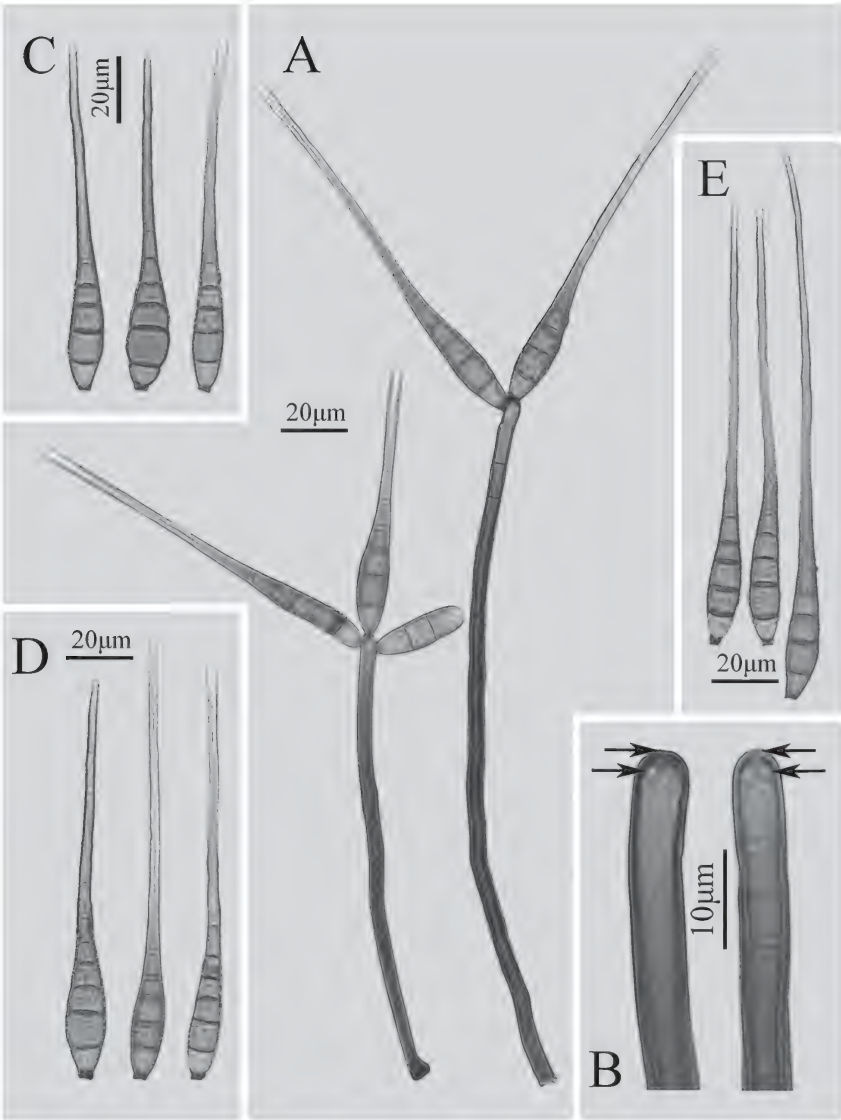


FIG. 1. *Spadicoides bawanglingensis* (holotype, HSAUP H6028). A. Conidiophores with conidia. B. Conidiogenous loci (arrowed). C–E. Conidia.

TYPE: China, Hainan Province: tropical forest of Bawangling, on dead stems of an unidentified broad-leaved tree, 16 Aug 2011, J.W. Xia (**Holotype**, HSAUP H6028; **isotype**, HMAS 243424).

ETYMOLOGY: in reference to the type locality.

COLONIES on natural substrate effuse, dark brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of septate, pale brown, smooth hyphae, 2–2.5 µm wide. CONIDIOPHORES differentiated, mononematous, unbranched, erect, straight or slightly flexuous, cylindrical, smooth, thick-walled, brown, 7–14-septate, 130–210 × 3.5–6 µm. CONIDIOGENOUS CELLS polytretic, integrated, terminal and intercalary, cylindrical, smooth, pale brown to brown. CONIDIA acropleurogenous, solitary, verrucose, 9–12-euseptate, obclavate, pale brown to brown, 98–166 µm long (rostrum included), 8.5–12.5 µm wide, 2.5–4.5 µm wide at the truncate base, apex extended into a pale brown to subhyaline, euseptate rostrum, 52–100 × 1–3 µm.

TABLE 1. Morphological comparison of *Spadicoides* species with obclavate conidia.*

SPECIES	CONIDIOPHORES (µm)	CONIDIA			
		WALL; COLOR	SIZE (µm)	SEPTA (#)	APEX; BASE
<i>S. bambusicola</i> ³	150–350 × 4–5	Verrucose; one color	30–72.5 × 5–7.5	5–7	Subacute; obconically truncate
<i>S. bawanglingensis</i>	130–210 × 3.5–6	Verrucose; one color	98–166 × 8.5–12.5	9–12	Rostrate; truncate
<i>S. heterocolorata</i> ¹	<420 × 6–10	Smooth; versicolored	16–25 × 3.5–5	Mostly 1	Slightly tapering; slightly protruding
<i>S. obclavata</i> ²	<550 × 5–8 (base), 4–5 (apex)	Smooth; versicolored	16–22 × 4–6	Mostly 2	Tapering; rounded
<i>S. palmicola</i> ¹	<780 × 7–15 (base), 4–5.5 (apex)	Smooth; versicolored	25–70 × 5–7	Mostly 4 or 5	Subacute, often rostrate; obconically truncate

* Data from ¹ Goh & Hyde (1999), ² Kuthubutheen & Nawawi (1991), and ³ Zhou et al. (1999).

COMMENTS – The conidiophores and conidia morphologies of *S. bawanglingensis* and four other *Spadicoides* species with obclavata conidia are compared in TABLE 1. *Spadicoides bambusicola* D.Q. Zhou et al., *S. heterocolorata* (R.F. Castañeda et al.) Goh & K.D. Hyde, *S. obclavata* Kuthub. & Nawawi, and *S. palmicola* Goh & K.D. Hyde can all be separated from *S. bawanglingensis* by their smaller conidia with fewer septa.

***Spadicoides longchiensis* J.W. Xia & X.G. Zhang, sp. nov.**

FIG. 2

MYCOBANK MB 807062

Differs from all other *Spadicoides* species by its oval to reniform conidia.

TYPE: China, Sichuan Province: national forest park of Longchi, on dead stems of unidentified broad-leaved tree, 17 Apr 2012, J.W. Xia (Holotype, HSAUP H6246; isotype, HMAS 243425).

ETYMOLOGY: in reference to the type locality.

COLONIES effuse on natural substrate, dark brown, hairy. Mycelium partly superficial, partly immersed. Hyphae branched, septate, pale brown, smooth.

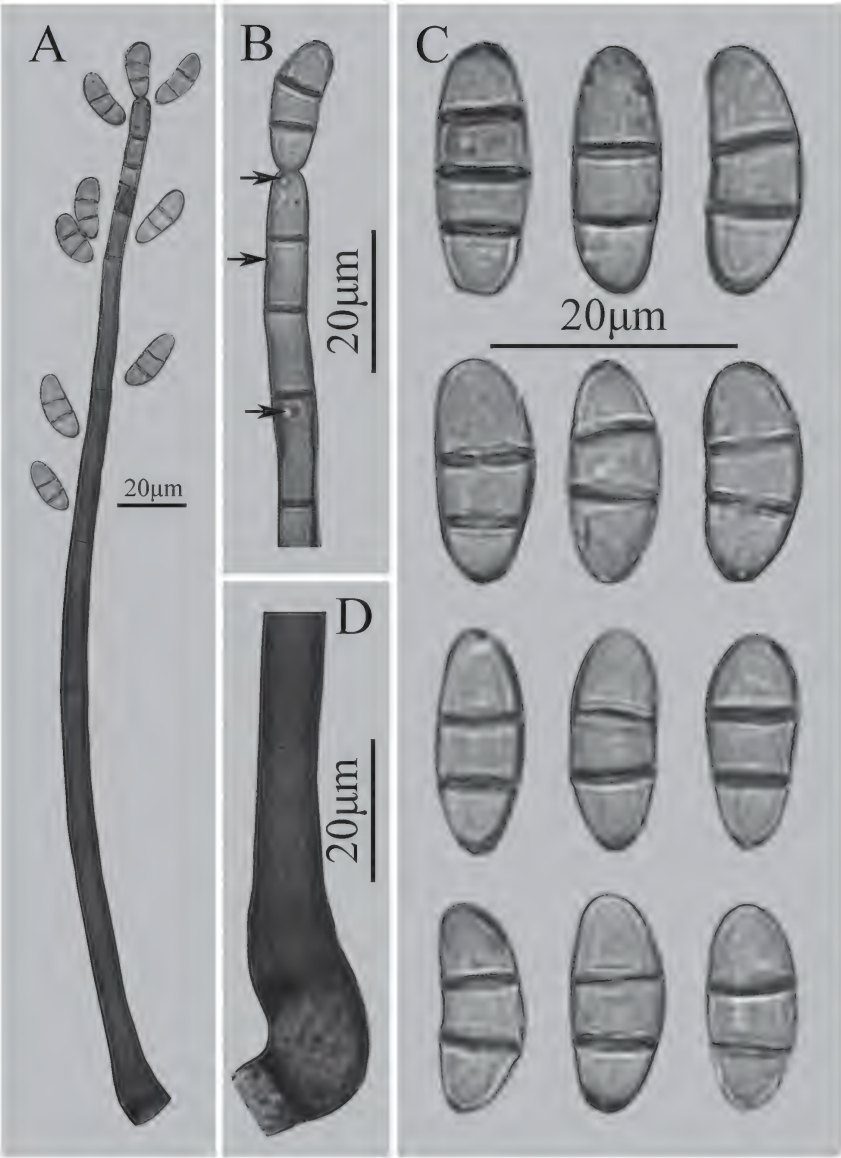


FIG. 2. *Spadicoides longchiensis* (holotype, HSAUP H6246). A. Conidiophore with conidia. B. Conidiogenous cells, conidiogenous loci (arrowed) and conidia. C. Conidia. D. Conidiophore basal cell.

CONIDIOPHORES macronematous, mononematous, single, unbranched, erect, straight or slightly flexuous, cylindrical, smooth, thick-walled, brown, 9–14-septate, $200\text{--}300 \times 5\text{--}8.5 \mu\text{m}$. CONIDIOGENOUS CELLS polytretic, integrated, terminal and intercalary, cylindrical, smooth, pale brown to brown. CONIDIA acropleurogenous, solitary, rounded at both ends, oval to reniform, 2–(3)-euseptate, mostly 2-euseptate, subhyaline to pale brown, smooth, $16\text{--}23 \mu\text{m}$ long, $6.5\text{--}8 \mu\text{m}$ wide in the broadest part.

COMMENTS – *Spadicoides longchiensis* resembles *S. klotzschii* S. Hughes in having smooth 2-septate conidia, but *S. klotzschii* differs by its smaller, clavate to ellipsoidal, versicolored conidia ($10\text{--}13 \times 4\text{--}5.5 \mu\text{m}$; Hughes 1973).

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MYCOTAXON

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***Entocybe haastii* from Watagans National Park,
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ABSTRACT — *Entocybe haastii* comb. nov. (*Entoloma haastii*) is distinguished by isodiametric minutely rounded pustulate-angular basidiospores, a dark blue black to nearly black pileus that lacks brown tones, dark blue grey lamellae, an appressed fibrillose blackish blue stipe, intracellular pigment in the pileipellis and inflated hyphae in the outer pileal trama, and the faintly parietal pigment on narrow pileal tramal hyphae.

KEY WORDS — *Basidiomycota*, *Entolomataceae*, new combination

Introduction

Entocybe T.J. Baroni et al. (*Basidiomycota*, *Agaricales*, *Entolomataceae*) was erected to accommodate a monophyletic group of species with the following set of morphological features: a slender tricholomatoid or mycenoid to collybioid habit, a relatively fragile, appressed fibrillose stipe, small, obscurely angular basidiospores with 6–10 facets (angles) in polar view and undulate-pustulate or rounded pustulate surface ornamentation overall, and a pileipellis subtended by inflated hyphae in the outer pileal trama (Baroni et al. 2011). An agaricoid fungus with this character set recently collected in Watagans National Park in central New South Wales was determined to be *Entoloma haastii*, a new report for mainland Australia. Herein, we recombine *E. haastii* in *Entocybe*.

Materials & methods**Macromorphological and micromorphological features**

Techniques and equipment for collecting and describing basidiomata in the field, GPS coordinates, microscopy of dried collection including how basidiospores were

TABLE 1. Collections used in the phylogenetic analyses.

SPECIES FROM GENBANK	COLLECTION IDENTIFIER	GENBANK ACCESSION NUMBERS		
		mtSSU	LSU	RPB2
<i>Calliderma</i> sp.	DLL 10025	JQ793648	JQ793642	—
	DLL 10054	—	JQ793649	—
	DLL 10088	JQ793643	JQ793650	JQ793657
<i>Clitocybe dealbata</i>	HC95cp	AF357138	AF223175	DQ825407
<i>Clitopilopsis hirneola</i>	8490TJB	GU384587	GU384611	GU384646
<i>Cl. hirneola</i> [<i>Clitopilus hirneolus</i>]	263	GQ289352	GQ289211	GQ289278
<i>Clitopilus cystidiatus</i>	26	GQ289287	GQ289147	GQ289220
<i>C. prunulus</i>	8229TJB	—	GU384615	GU384650
	9663TJB	GU384586	GU384614	GU384648
<i>C. “cinerascens”</i>	8024TJB	GU384585	GU384613	GU384647
<i>Entocybe haastii</i>	DLL 9868	JQ793644	JQ793651	JQ793658
	DLL 10087	JQ793645	JQ793652	JQ793659
<i>Entc. haastii</i> [<i>Entoloma haastii</i>]	126	GQ289307	GQ289167	GQ289238
<i>Entc. nitida</i> [<i>E. nitidum</i>]	7526TJB	GU384602	GU384626	GU384655
	s	GQ289315	—	GQ289246
<i>Entc. nitida</i> [<i>E. alcedicolor</i>]	210	GQ289292	GQ289152	GQ289224
<i>Entc. trachyospora</i> [<i>E. trachyosporum</i>]	414	GQ289339	GQ289199	—
	405	GQ289338	GQ289198	—
<i>Entc. trachyospora</i> [<i>R. trachyospora</i>]	5856TJB	GU384605	GU384629	GU384658
<i>Entc. turbida</i> [<i>E. turbidum</i>]	27	GQ289341	GQ289201	GQ289269
	6949TJB	GQ289341	GQ289201	GQ289269
<i>Entc. vinacea</i> [<i>E. vinaceum</i>]	8870TJB	GU384598	GU384631	GU384651
<i>E. bloxamii</i>	219	GQ289294	GQ289154	GQ289226
<i>E. caesiolamellatum</i> [<i>E. bloxamii</i>]	6117TJB	—	AF261289	—
<i>E. coeruleogracilis</i> [<i>E. haastii</i>]	216	GQ289308	GQ289168	GQ289239
	217	GQ289309	GQ289169	GQ289240
<i>E. cretaceum</i>	213	GQ289302	GQ289162	GQ289233
<i>E. gelatinosum</i>	212	GQ289305	GQ289165	GQ289236
<i>E. griseolazulinum</i>	111	GQ289306	GQ289166	GQ289237
<i>E. indigoticoumbrinum</i>	83	GQ289318	GQ289178	GQ289249
<i>E. kermantii</i>	222	GQ289313	GQ289173	GQ289244
<i>E. perbloxamii</i>	71	GQ289318	GQ289178	GQ289249
<i>E. prunuloides</i>	40	GQ289324	GQ289184	GQ289255
<i>Entoloma</i> sp.	DLL 10217	JQ793646	JQ793653	JQ793660
	BY21	—	AF261309	—
	DLL 10055	—	JQ793655	JQ793662
<i>Lepista ovispora</i>	442	GQ289347	GQ289207	GQ289274
<i>Rhodocybe</i> sp. [<i>Clitopilus</i> sp.]	211	GQ289353	GQ289212	GQ289279
<i>R. aureicystidiata</i>	PBM1902	—	AY380407	AY337412
<i>R. caelata</i> [<i>C. caelatus</i>]	6995TJB	GU384600	GU384625	GU384652
<i>R. fallax</i>	CBS129.63	AF357083	AF223166	EF421051
<i>R. fallax</i> [<i>C. fallax</i>]	262	GQ289349	GQ289210	GQ289275
	37	GQ289350	GQ289276	GQ289276
<i>R. mundula</i>	7599TJB	—	AY700182	DQ474128
<i>R. nitellina</i> [<i>C. nitellinus</i>]	265	GQ289354	GQ289214	GQ289281
	400	GQ289355	GQ289215	GQ289282
<i>R. pallidogrisea</i> [<i>C. pallidogriseus</i>]	118	GQ289356	GQ289216	GQ289283
<i>R. popinalis</i> [<i>C. popinalis</i>]	260	—	GQ289213	GQ289280
<i>R. popinalis</i>	6378TJB	GU384601	AF261285	GU384654
<i>R. pruinostipitata</i>	MCA1492	GU384608	GU384627	GU384653
<i>R. pseudopiperita</i> [<i>C. pseudopiperitus</i>]	162	GQ289357	GQ289217	GQ289284
<i>R. spongiosa</i>	MCA2129	GU384604	GU384628	GU384657
<i>Tricholoma vaccinum</i>	446	GQ289358	GQ289219	GQ289286
<i>T. viridiolivaceum</i>	PBM3093	—	JF706317	JF706319

New sequences generated for this study are shown in bold. Square bracketed annotations indicate species names applied in GenBank that differ from those in the phylogram (Fig. 1).

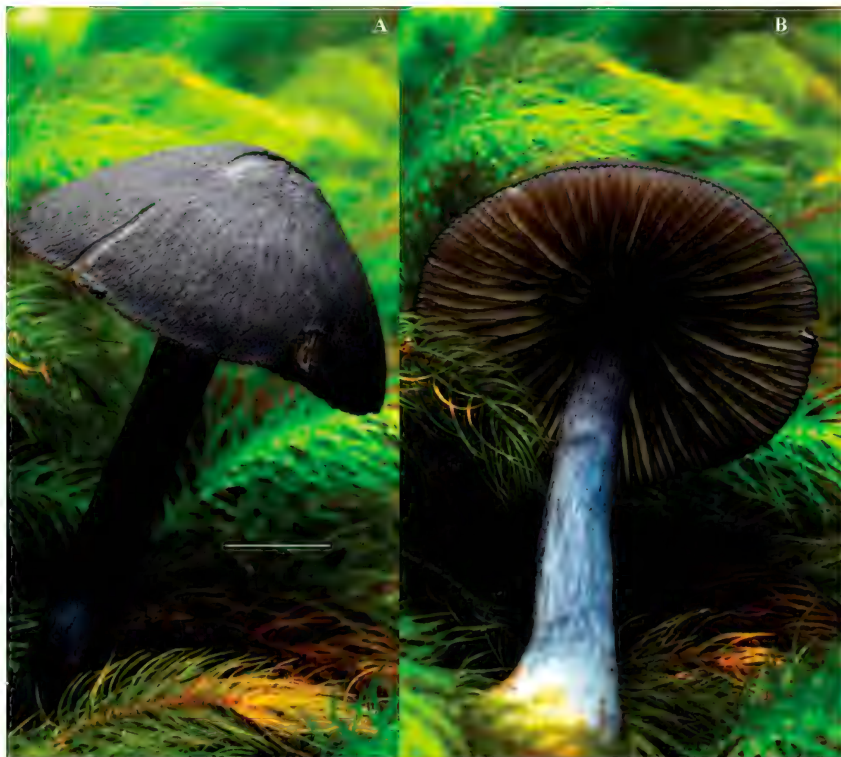


PLATE 1. *Entocybe haastii* {DLL 10087}. A: Densely appressed-fibrillose pileus surface; B: Dark bluish-grey lamellae and stipe apex. Bar (A, B) = 5 mm.

measured, and digital microphotographs have been described in Largent et al. (2011a,b), while techniques for describing, coding, naming colors from Kornerup & Wanscher (1978) and factors determined from mathematical analyses in the descriptions are covered in Largent et al. (2013). Generic abbreviations used are: *E.* = *Entoloma*; *Entc.* = *Entocybe*.

The holotype collection and one additional collection are deposited in The Plant Pathology Herbarium, Orange Agricultural Institute (DAR). The herbarium acronym is from Thiers (2012).

DNA sequences

Sequences were obtained for three loci (mtSSU, LSU, RPB2) for two *E. haastii* collections from Australia (TABLE 1). The extraction and Polymerase Chain Amplification (PCR) protocols for the mitochondrial small subunit of the ribosomal DNA (mtSSU), variable domains (D1, D2) of the nuclear large subunit (LSU) and the second largest subunit of the RNA polymerase gene (RPB2) follow Largent et al. (2011b). The primers rpb2-i6f and rpb2-i7r or rpb2-EntF2 and rpb2-EntR4 were used to amplify the RPB2 (Co-David et al. 2009, Largent et al. 2013). Sequences were generated on an Applied

Biosystems 3130xl Genetic Analyzer at Middle Tennessee State University using the sequencing protocols outlined in Largent et al. (2011b).

Sequences were assembled and edited using Sequencher ver. 4.2.2 (Gene Codes Corporation, Ann Arbor, MI) and multiple sequence alignments were generated using MAFFT version 7.1 (Katoh & Standley 2013) and adjusted manually using Se-Al ver. 2.0a11 Carbon (Rambaut 2002) after exclusion of introns from the RPB2 alignment. The combined mtSSU, LSU and RPB2 sequences were aligned with closely related sequences from GenBank within the *Prunuloides* clade, representatives of the basal *Rhodocybe-Clitopilus* clade, and appropriate outgroups (Matheny & Baroni 2011) (TABLE 1). The alignment lengths were 1909 bp (mtSSU), 1472 bp (LSU), and 972 bp (RPB2).

The sequence alignment was analyzed using a Maximum Likelihood (ML) search GTRGAMMA model using RAXML-HPC v. 7.2.8 ALPHA (Stamatakis 2006). The dataset was partitioned using 4 partitions: RPB2 (across each codon position), mtSSU and LSU. Bootstrap proportions were estimated based on 1000 rapid ML replicates and 1000 bootstrap replicates (Stamatikas et al. 2008).

Results

The best likelihood tree in RaxML showed that species identified as *Entocybe* (Baroni et al. 2011) formed a well-supported clade (BS = 97, Figure 1) and lends further support for the generic concept as defined by Baroni et al. (2011). Additional comments on *Entc. haastii* are provided in the Comments section.

Taxonomy

Entocybe haastii (G. Stev.) Largent, **comb. nov.**

PLATES 1–3

MYCOBANK MB 804015

≡ *Entoloma haastii* G. Stev., Kew Bull. 16(2): 229 (1962).

HABIT mycenoid but with a broad stipe base. **PILEUS** 24–33 mm broad, 10–11 mm high, umbo obscurely broad, opaque, not hygrophanous, not translucent-striate, dull, moist but not sticky, conic- or convex-campanulate, densely appressed- or matted-fibrillose, rivulose, dark blackish blue (19F3 or 19F3–4) to nearly black, lacking any brown color, becoming silky or satiny appressed fibrillose with maturity; margin decurved, entire becoming slightly eroded; context 0.75–2.0 mm thick above the stipe, ± violaceous. **ODOR** mild or faintly fragrant. **TASTE** mild, at times suggestively sweet. **LAMELLAE** 11–15 mm long, 5.5–11.0 mm broad, narrowly adnate or adnate, close, at first dark bluish grey (19E-F2–3) with basidiospore maturity pale orange (6A3) then orange grey (6B2); margin smooth and concolorous. **STIPE** 40–65 3–5 (apex) – 4–10 mm (middle) – 6–12 (base) mm, clavate, shiny and glossy, appressed-fibrillose, blackish blue but somewhat lighter than the pileus (19E5 or 20F6), white or yellowish white at the base, hollow and splits longitudinally with ease; context cartilaginous, white at least at the base; basal tomentum absent. **BRUISING REACTIONS** none.



PLATE 2. *Entocybe haastii* {DLL 9868 A, B; DLL 10087 C}. A: Stature; B: Mature lamellae; C: Mature pileal surface. Bar for A, B = 15 mm; C = 10 mm.

BASIDIOSPORES in squashed mounts of lamellae in 3% KOH often collapsed and thin-walled, some distinctly angular and some indistinctly to faintly rounded pustulate, in mounts from stipe surface decidedly rounded pustulate with 6 or more facets, in profile view isodiametric to subsodiametric, rarely heterodiametric, in polar view isodiametric $6.4\text{--}9.5(-10.2) \times 5.5\text{--}7.9(-9.0) \mu\text{m}$ ($x = 7.7 \pm 0.7 \times 6.9 \pm 0.6 \mu\text{m}$; $E = 0.96\text{--}1.31$, $Q = 1.11 \pm 0.07$ (isodiametric); $n = 90/2$). BASIDIA cylindro-clavate, hardly tapered, $26.2\text{--}39.8 \times 7.7\text{--}11.7 \mu\text{m}$ ($x = 32.1 \pm 3.8 \times 9.5 \pm 1.0 \mu\text{m}$; $E = 2.51\text{--}4.42$, $Q = 3.41 \pm 0.48$; $n = 26/2$); 2- or 4-sterigmate. HYMENIAL CYSTIDIA absent. LAMELLAR TRAMAL HYPHAE subparallel, moderately short and broad, $48.2\text{--}131.3 \times 7\text{--}30.2 \mu\text{m}$. PILEIPELLIS mostly a multi-layered cutis with a few semi-erect terminal cells, subtended by inflated cells of the pileal trama. PILEOCYSTIDIA (terminal cells) cylindric to narrowly obclavate, $54.1\text{--}81.1 \times 2.5\text{--}7.8 \mu\text{m}$ ($n = 7/1$). PILEAL TRAMAL HYPHAE beneath the pileipellis, short, broad and inflated, $47\text{--}129 \times 8\text{--}22 \mu\text{m}$

enlarging up to 188 μm long and 33 μm wide near the hymenium ($n = 14/2$). STIPITIPPELLIS a cutis. CAULOCYSTIDIA and HYMENIAL CLUSTERS absent. OLEIFEROUS HYPHAE rare to scattered in the pileal trama. LIPOID GLOBULES absent. BRILLIANT GRANULES absent. PIGMENTS cytoplasmic, brownish blue, soluble in 3% KOH in pileipellis and inflated hyphae of outer pileal trama; faintly parietal or possibly encrusted on the narrow hyphae of the pileal trama. CLAMP CONNECTIONS present on hyphae of all tissues.

ECOLOGY and DISTRIBUTION — solitary in soil among leaf litter or in mosses on a rock, warm gallery rainforest, Watagans National Park, New South Wales.

COLLECTIONS EXAMINED – AUSTRALIA. NEW SOUTH WALES, Central Hunter District, the Watagans National Park, Boardinghouse Dam Track, 32°59'58.6"S 151°24'15.5"E, 13 April 2010, DL Largent 9868 (DAR); 32°59'56"S 151°24'15"E, 12 April 2011, DL Largent 10087 (DAR).

COMMENTS — *Entocybe haastii* from New South Wales lacks the brown color in the pileus reported for this species from Tasmania and New Zealand (Noordeloos & Gates 2012). The lamellae from Tasmania are whitish while those from Australia and New Zealand are bluish-gray (Horak 2008, Noordeloos & Gates 2012). This variability suggests that fine color distinctions are not diagnostic for *Entc. haastii*.

Similar to *Entc. haastii*, both *Entc. nitida* (Quel.) T.J. Baroni et al. ($\equiv$ *Entoloma nitidum* Quél.) from Europe and *Entoloma alcedicolor* Arnolds & Noordel. from Holland have small isodiametric basidiospores and abundant clamp connections and lack cheilocystidia (Noordeloos 2004).

Entocybe nitida is distinguished from *Entc. haastii* by a glabrous or radially fibrillose pileus, white 30–100 mm long immature lamellae, ≤ 100 mm long cylindrical stipe, slightly farinaceous or raphanoid odor, and shorter and broader tramal cells subtending the pileipellis (Noordeloos 1981, 1992, 2004). Although Noordeloos (1992) identified basidiomata from Germany with bluish lamellae as *Entc. nitidum*, identification remains speculative as no collection was retained.

Entoloma alcedicolor differs from *Entc. haastii* by its steel blue pileus and stipe, garlic odor, squamulose pileus center, and trichodermial pileipellis on the center of the pileus.

Entoloma gracilior Noordel. & G.M. Gates from Tasmania, which shares with *Entc. haastii* black pilei, lilac grey lamellae, a dark blue stipe as well as a similar pileipellis and basidiospores, differs in its more mycenoid stature and more slender (2–4 mm across the apex) equal stipe, a weakly hygrophanous smooth pileus with a translucent-striate margin, and heterodiametric basidiospores (Noordeloos & Gates 2012).

Entoloma coeruleogracilis G.M. Gates & Noordel., also from Tasmania, is distinguished by its sky blue stipe and pileus with a violet hue and the 1–3 mm broad cylindrical stipe.

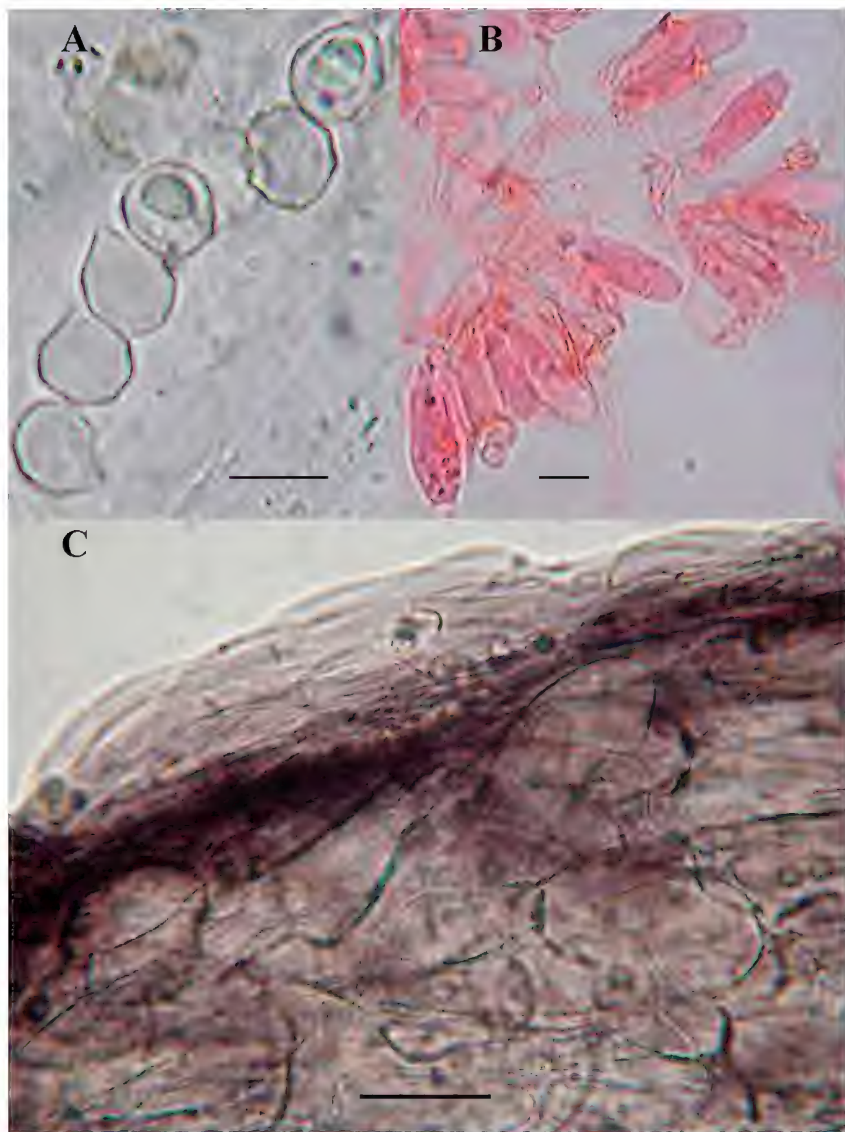


PLATE 3. *Entocybe haastii* {DLL 10087}. A: Basidiospores from stipe surface; B: Basidia and basidioles; C: Pileipellis and subtending inflated cells in pileal trama. Bars A = 7.0 μm ; B = 10 μm ; C = 22 μm .

Our phylogenetic analysis (FIG. 1) clearly supports (BS = 97) *Entc. haastii* within *Entocybe* as described by Baroni et al. (2011). *Entocybe haastii*, *E. coeruleogracilis*, *Entc. nitida*, and *E. alcedicolor* segregate as a sub-clade with

moderate support (BS = 77). Noordeloos & Gates (2012) classify these taxa in *Entoloma* sect. *Nitida* (Romagn.) Noordel. based on a number of morphological features.

Acknowledgments

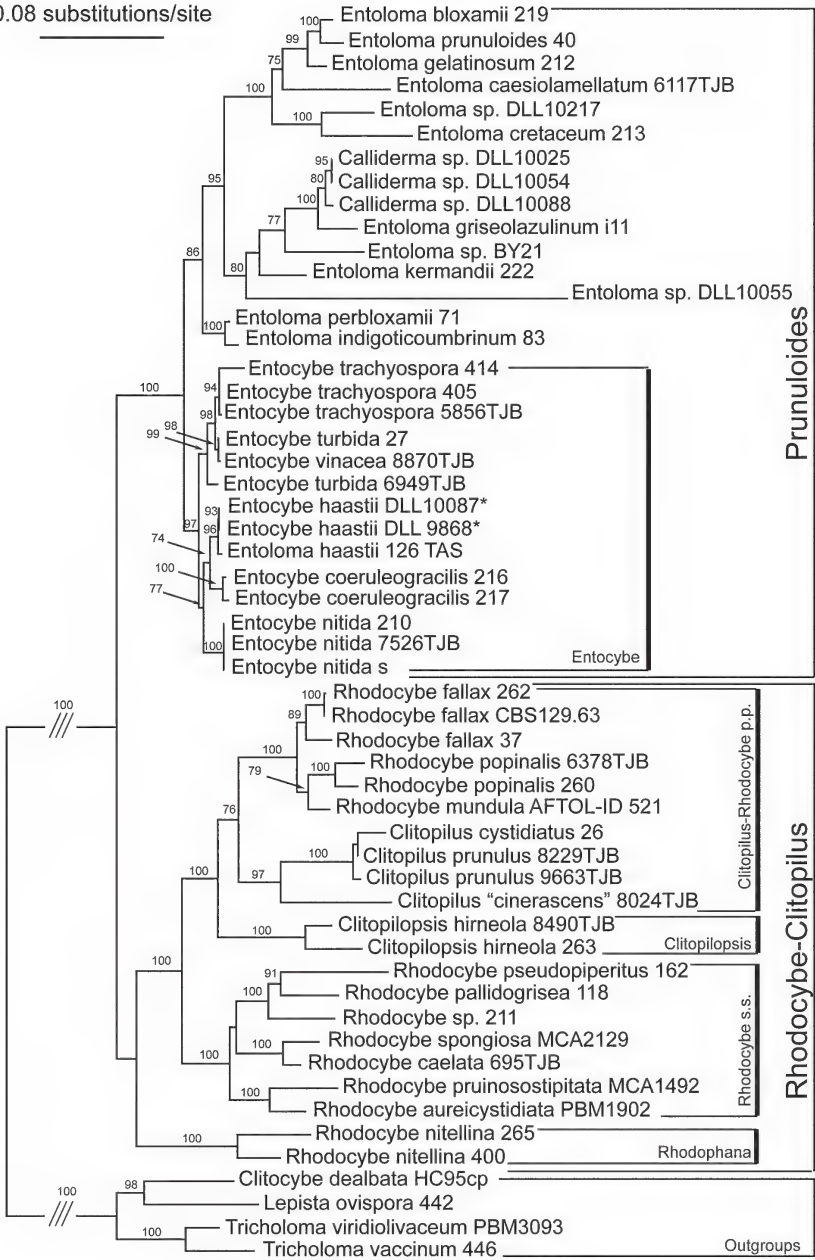
Fieldwork in Australia was supported by the Largent family trust and we are particularly grateful for the support of Pamela Largent. Fieldwork and logistical support were provided by the Australian Tropical Herbarium and the School of Marine and Tropical Biology, James Cook University. Comments by the two reviewers, Dr. Timothy J. Baroni and Dr. Terry W. Henkel, and Ms. Fernanda Karstedt and Nomenclature Editor Dr. Shaun Pennycook are also appreciated. We wish to thank Pam O'Sullivan as well as Skye Moore for their assistance in providing descriptions and sharing the location of collecting sites in New South Wales.

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FIGURE 1. Maximum likelihood tree (LSU+mtSSU+RPB2) showing the position of *Entocybe haastii* from Australia (AUS*) and Tasmania (TAS) relative to other *Entocybe* collections. Each sequence is labeled with the GenBank-listed isolate number. Branches with >70% support from 1000 rapid bootstraps provide statistical support. *Clitocybe dealbata*, *Lepista ovispora*, *Tricholoma vaccinum*, and *T. virdiviolaceum* serve as outgroups. Three slanted lines denote truncated branches.

0.08 substitutions/site



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MYCOTAXON

<http://dx.doi.org/10.5248/126.71>

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***Craterium corniculatum* sp. nov. from northwestern China**BO ZHANG¹ & YU LI^{1*}¹Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi,
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ABSTRACT — *Craterium corniculatum* is a new species collected in Gansu Province, China, characterized by horned sporophores and warted spores. We provide a morphological description, illustrations, and a key to the 17 *Craterium* species. The specimens were deposited in the Herbarium of Mycological Institute of Jilin Agricultural University (HMJAU), Changchun, China.

KEY WORDS — taxonomy, SEM, slime molds, *Myxogastrea*, *Physaraceae*

Introduction

Myxomycetes are common inhabitants of decaying plant materials in nature, such as decaying logs, stumps, and dead leaves (Stephenson & Stempen 1994). Trentepohl established the genus *Craterium* in 1797 for myxomycetes with stalked sporophores, a persistent basal cup, and subglobose or turbinate obovate sporocarps that show a distinct or indistinct lid during dehiscence (Martin & Alexopoulos 1969). In 2012 we found a new species on the bark of a dead log on Jilian Mountain, Gansu Province, China, that differs morphologically from all other *Craterium* species.

Materials & methods

The fruiting bodies and microscopic structures were examined by light and scanning electron microscopes (Martin & Alexopoulos 1969, Zhang & Li 2013). Permanent slides were mounted in Hoyer's reagent (Martin & Alexopoulos 1969). We prepared them according to Robbrecht (1974) by spreading capillitia in a drop of 94% alcohol, determining colour after one minute, and then mounting in Hoyer's reagent. Colour terms are given according to Flora of British Fungi (Royal Botanic Garden Edinburgh 1969).

We observed more than ten sporocarps under a stereomicroscope (20×) and more than 20 spores under an optical microscope (100×). The sporophores, capillitia, and

spores were measured by using a Nikon DM1000 microscope and photographed with a Canon G15 camera. For ultrastructural observation, the sporophores were attached to the holder, coated with gold using a Hitachi E-1010 sputter, and examined with a Hitachi S-4800 scanning electron microscope at 10 kV at Changchun Institute of Applied Chemistry, Chinese Academy of Sciences. The specimens were deposited in the Herbarium of Mycological Institute, Jilin Agricultural University (HMJAU).

Taxonomy

Craterium corniculatum B. Zhang & Yu Li, sp. nov.

PLATE 1

MYCOBANK MB 806043

Differs from *Craterium aureomagnum* and *C. aureum* by its horned sporophores and warted spores.

TYPE: China, Gansu Province, Jilan Mountain, on bark of a dead log, 6 August 2012, Zhang Bo 20122203, (Holotype, HMJAU10550).

ETYMOLOGY: corniculatus (Latin), referring to the 'horned' sporophores.

SPOROPHORES gregarious, in small groups, shortly stalked or nearly sessile, 0.25–0.75 mm tall. Sporotheca subglobose or pyriform to irregular, 0.2–0.5 mm in diam. HYPOTHALLUM conspicuous, membranous, pale yellow, veined with ribs radiating from the sporocarp base. STALK either lacking, or very short and consisting of updrawn hypothallus, strongly ribbed, yellowish brown, pale brown in transmitted light. LID paler than cup, usually with a paler calcareous deposit, yellowish pale by transmitted light, with pale dehiscence lines and circumscissile area. PERIDIUM thick, single, cartilaginous, containing small lime. CAPILLITIUM rather dense, lime nodes rounded or angular, large, pale yellowish brown by transmitted light, 40×70 – 80 – 100 μm . SPORES free, fuscous black in mass, dark brown by transmitted light, subglobose, 8–14 μm diam., densely warted.

ADDITIONAL SPECIMEN EXAMINED: CHINA, GANSU PROVINCE, Jilan Mountain, on bark of a dead log, 26 August 2010, Zhang Bo 20101201 (HMJAU10551).

COMMENTS: Of the 16 species reported for *Craterium* Trentep. (Kirk et al. 2008, Lado 2005–13), seven have been found in China: *C. aureum* (Schumach.) Rostaf., *C. concinnum* Rex, *C. leucocephalum* (Pers. ex J.F. Gmel.) Ditmar, *C. microcarpum* H.Z. Li et al., *C. minutum* (Leers) Fr., *C. obovatum* Peck, and *C. rubronodum* G. Lister (Li & Li 1989, Li et al. 1993). Among the 16 accepted species, only *C. aureomagnum* Hooff & Nann.-Bremek. and *C. aureum* are similar to *C. corniculatum* in having yellow sporocarps, but *C. aureomagnum* has larger sporocarps (0.7–1.5 mm tall), double peridia, and darker and prominently warted spores that are 10–12 μm in diam. (Hooff & Nannenga-Bremekamp 1996), while *C. aureum* has stalked, turbinate, or obovoid sporocarps that are 0.7–1.0 mm tall and lemon-yellow to almost white (Rostafinski 1974).

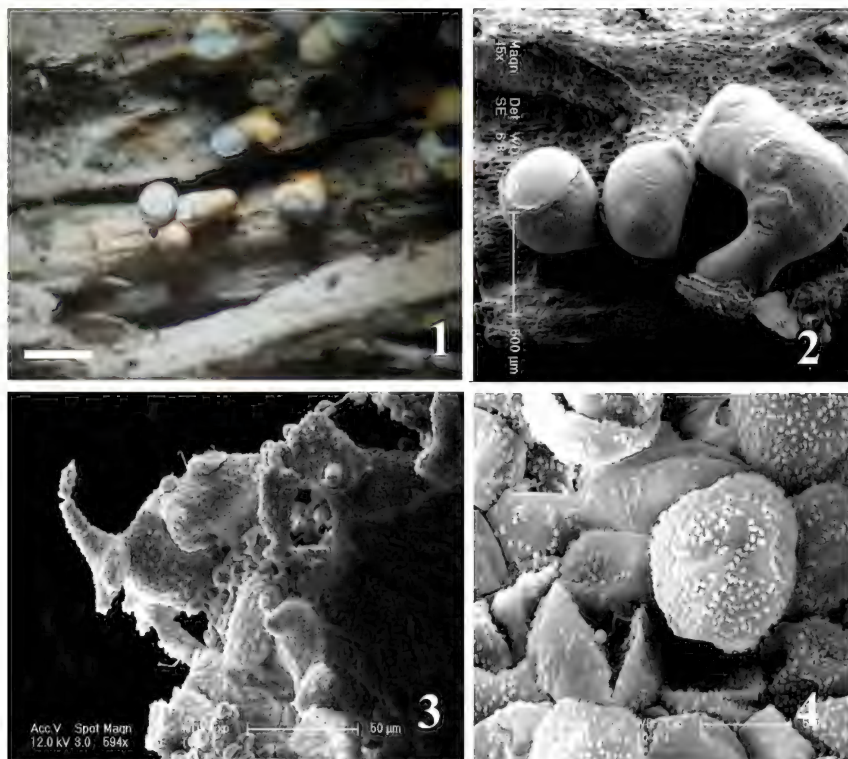


PLATE 1. *Craterium corniculatum* (Holotype, HMJAU 10550): 1–2, fruiting bodies; 3, capillitium; 4, densely warted spores. Scale bar: 1 = 2 mm.

Key to species of *Craterium*

1. Sporophores dehiscing by a distinct lid 2
1. Sporophores not dehiscing by a distinct lid 8
2. Spores reticulate *C. retisporum*
2. Spores spinulose and warted 3
3. Spores <10 µm in diam. 4
3. Spores >10 µm in diam. 6
4. Lid dome shaped, fragmenting by preformed lines at dehiscence 5
4. Lid convex or fat, not veined, remaining whole at dehiscence 7
5. Sporocarps 0.15–0.41 mm high; spores 8–10 µm in diam. *C. microcarpum*
5. Sporocarps 0.6–1 mm high; spores 7–9 µm in diam. *C. reticulatum*
6. Sporocarps short (0.5–0.8 mm high); spores 9–10 µm in diam. *C. concinnum*
6. Sporocarps taller (≤1.5 mm high); spores 8–10 µm in diam. *C. minutum*

7. Spores 10–12 μm in diam. with 1 μm tall spines *C. rubronodum*
 7. Spores 13–15 μm in diam. with groups of confluent spines *C. costatum*
 8. Sporophores obconic; becoming cup-shaped after dehiscence 9
 8. Sporophores obovoid, turbinate, corniculate; dehiscence irregular 10
 9. Sporocarps usually stalked; spores 7–10 μm in diam. *C. leucocephalum*
 9. Sporocarps sessile or short-stalked; spores 9–10 μm in diam. *C. aureonucleatum*
 10. Sporocarps yellow 11
 10. Sporocarps bright pink, purplish pink, red brown 13
 11. Sporocarps stalked *C. aureum*
 11. Sporocarps sessile or very short-stalked 12
 12. Sporocarps subcylindric; spores 10–12 μm in diam. *C. aureomagnum*
 12. Sporocarps corniculate; spores 8–14 μm in diam. *C. corniculatum*
 13. Sporocarps bright pink, purplish pink *C. paraguayense*
 13. Sporocarps red brown, purplish brown, dark brown to black 14
 14. Spores warted, <13 μm in diam. *C. atrolucens*
 14. Spores coarsely warted, subreticulate or reticulate, >13 μm in diam. 15
 15. Spores with dark prominent warts *C. obovatum*
 15. Spores subreticulate or reticulate 16
 16. Spores marked with an incomplete net of broad spines fusing into short ridges,
 14–17 μm in diam. *C. dictyosporum*
 16. Spores loosely reticulate by ridges about 1 μm high, 13–16 μm in
 diam. *C. muscorum*

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MYCOTAXON

<http://dx.doi.org/10.5248/126.77>

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***Embryonispora*, a new genus of hyphomycetes from China**KAI-NING ZHAO¹, GUO-HUA YIN², GUO-ZHU ZHAO^{1*} & AI-XIN CAO³¹*College of Biological Sciences and Biotechnology, Beijing Forestry University,
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ABSTRACT — *Embryonispora bambusicola* gen. & sp. nov., found on dead culms of bamboo and dead branches of an unidentified tree in China, is described and illustrated. The genus is characterized by sporodochial conidiomata and muriform, reniform or flattened, dorsiventrally curved, pale brown to brown conidia. The new taxon is compared with morphologically close related genera and species.

KEY WORDS — anamorphic fungi, dictyosporous fungi, taxonomy

Introduction

In a study of dictyosporous hyphomycetes from China, several fungal specimens were collected between 2002 and 2003. A fungus with sporodochial pulvinate or effuse conidiomata and flattened dorsiventrally curved muriform embryoniform conidia was found among them. It cannot be assigned to any previously described genus and therefore is described here as new.

Materials & methods

Decayed waste wood was collected in the field of Zhejiang and Hainan Province, China. Samples were placed separately into plastic or paper bags and stored in a refrigerator at 4°C before microscopic study. They were incubated to induce sporulation in moist containers (plastic bags or boxes) at room temperature. Humidity was maintained by adding moistened paper towels. The incubated samples were examined microscopically for the presence of microfungi after 4–5 days and up to one month. Sporulated colonies were removed from the surface of the wood with a needle and transferred to a drop of lactophenol on a microscope slide. Extensive attempts to culture fungi on artificial media (water agar, 2% malt extract agar) failed. Digital photomicrographs were taken using an Olympus BX-51 microscope. Herbarium specimens and slides were deposited

in HSAUP (Herbarium of Shandong Agricultural University: Plant Pathology) and HMAS (Herbarium of Mycology, Chinese Academy of Sciences).

Taxonomy

Embryonispora G.Z. Zhao, gen. nov.

MYCOBANK MB 802690

Differs from other sporodochial genera by its reniform and dorsiventrally curved conidia.

TYPE SPECIES: *Embryonispora bambusicola* G.Z. Zhao

ETYMOLOGY: *Embryonispora*, referring to the conidia, which are shaped like a human embryo.

Conidiomata on natural substrate sporodochial, superficial, olivaceous, brown to dark brown. Mycelium partly superficial and partly immersed. Conidiophores undifferentiated, reduced to conidiogenous cells. Conidiogenous cells monoblastic, integrated, terminal, determinate. Conidial secession schizolytic. Conidia solitary, acrogenous, embryoniform or reniform, curved dorsiventrally, flattened from side to side, sometimes variable in shape, muriform, with longitudinal, transverse and oblique septa, with 1–2 layers of cells, holoblastic, olivaceous, pale brown to brown.

Embryonispora bambusicola G.Z. Zhao, sp. nov.

FIGS 1, 2

MYCOBANK MB 802691

Differs from other sporodochial species by its reniform, dorsiventrally curved, muriform conidia usually composed of 1–2 layers of marginal cells and some irregular protruding core cells.

TYPE: China. Zhejiang Province, Hangzhou Botanical Garden, on dead bamboo culms, 12 August 2002, coll. G.Z. Zhao ZGZII₀₂172 (Holotype, HSAUP0972).

ETYMOLOGY: *bambusicola*, referring to the host on which the taxon was first found.

Conidiomata on natural substrate sporodochial, scattered to confluent, pulvinate, brown to dark brown. Mycelium superficial and immersed, composed of septate, pale brown to brown, smooth-walled, branched hyphae. Conidiophores undifferentiated. Conidiogenous cells monoblastic, integrated, pale brown, determinate, cylindrical. Conidial secession schizolytic. Conidia solitary, curved dorsiventrally, embryoniform or cerebriform, muriform, with longitudinal, transverse and oblique septa, often constricted at the septa, usually composed of 1–2 layers of marginal cells and some irregular protruding core cells, holoblastic, olivaceous, pale brown to brown, $16\text{--}22 \times 12\text{--}16\text{ }\mu\text{m}$, $9\text{--}11\text{ }\mu\text{m}$ thick. Basal cell protruding, obconical to cylindrical, subhyaline to pale brown, truncate, $1.5\text{--}2.5\text{ }\mu\text{m}$ wide.

ADDITIONAL SPECIMEN EXAMINED: CHINA. HAINAN PROVINCE, Wuzhishan, on dead branches of an unidentified tree, 14 December 2003, coll. G.Z. Zhao ZGZII₀₃106-2 (HMAS 90279).

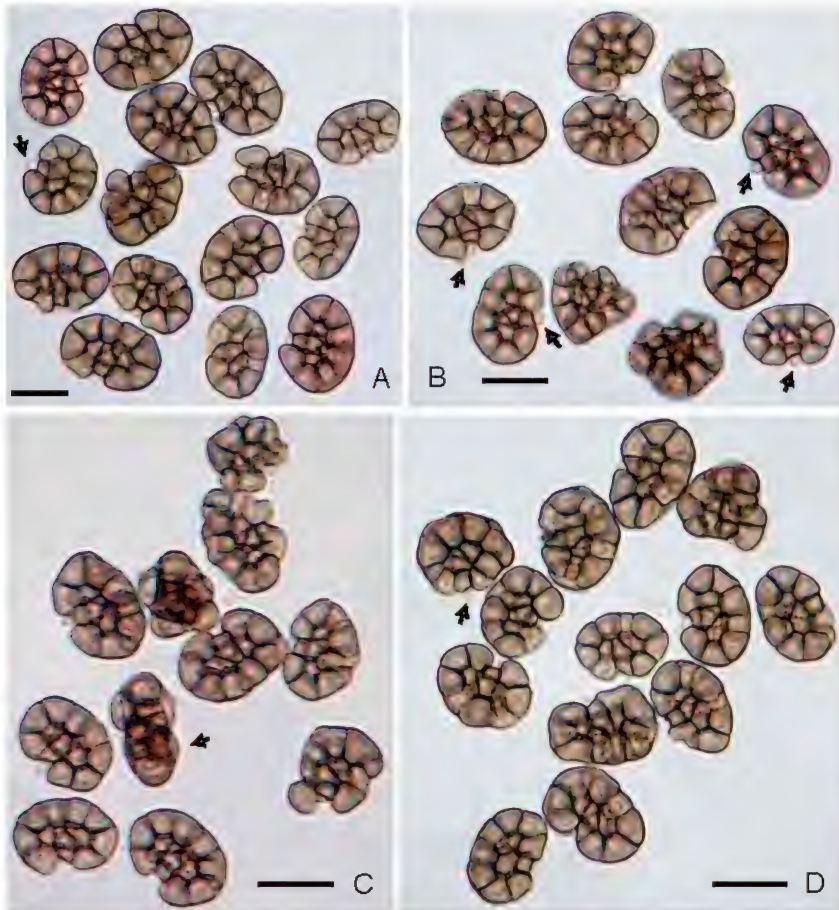


FIG. 1. *Embryonispora bambusicola* (holotype HSAUP0972).

A–D. Conidia; arrows show pale brown basal cells and conidia in side view. Bars = 10 μm

Discussion

Several genera with sporodochial conidiomata, less differentiated conidiophores, and muriform conidia are morphologically similar to *Embryonispora*. They include *Canalisporium* Nawawi & Kuthub., *Dictyosporium* Corda, *Turturconchata* J.L. Chen et al. (= *Venustusporium* R.F. Castañeda & Iturr., now corrected to “*Venustisporium*” in accordance with Art. 60.8 of the International Code of Nomenclature, McNeill & al. 2012), *Oncopodiella* G. Arnaud ex Rifai, *Petrakia* Syd. & P. Syd., *Oncopodium* Sacc., and *Hermatomyces* Speg. (Ellis 1971, 1976; Nawawi & Kuthubutheen 1989; Chen et al. 1999; Castañeda & Iturriaga 1999; Chung & Tzean 2000). *Canalisporium* and

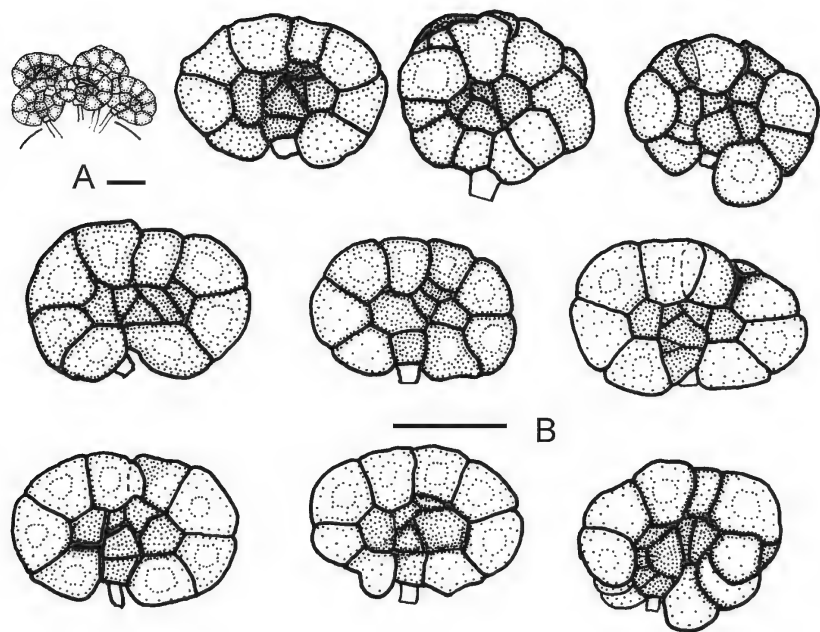


FIG. 2. *Embryonispora bambusicola* (holotype HSAUP0972).
A. Sporodochium with conidia; B. Mature conidia with pale brown basal cells. Bars = 10 μm

Dictyosporium can be separated from *Embryonispora* by having cheiroid, fan-shaped, regularly muriform, flattened conidia, which are usually composed of columns or rows of cells. The conidia of *Turturconchata* are borne horizontally flattened, muriform, margin irregular, somewhat crenate, eccentric protuberate pedicel, while those of *E. bambusicola* are vertically dorsiventrally curved and muriform. *Oncopodiella* and *Petrakia* differ from *Embryonispora* by producing muriform conidia with hyaline horn-like protruding cells. *Oncopodium* is distinct from *Embryonispora* in having conidia that commonly contain swollen basal cells. *Hermatomyces* differs from *Embryonispora* in the presence of lenticular conidia.

Key to *Embryonispora* and morphologically similar genera

- 1. Conidia usually flattened 2
- 1. Conidia not flattened, with protruding hyaline horn-like cells 3
- 2. Conidia dorsiventrally curved. 4
- 2. Conidia shaped differently 6

- 3. Horn-like cells >8 µm *Petrakia*
- 3. Horn-like cells shorter, <8 µm *Oncopodiella*
- 4. Conidia subglobose or hemispherical, clathrate or muriform *Oncopodium*
- 4. Conidia shaped differently..... 5
- 5. Conidia embryoniform or cerebriform, muriform *Embryonispora*
- 5. Conidia horizontally, flattened, muriform, margin irregular, somewhat crenate,
eccentric protuberate pedicel *Turturconchata*
- 6. Conidia lenticular, muriform, with pale peripheral cells surrounding the central
cells *Hermatomyces*
- 6. Conidia shaped differently..... 7
- 7. Conidia usually cheiroid, composed of columns or rows of cells *Dictyosporium*
- 7. Conidia broadly ellipsoidal, with cell lumen connected by narrow
canals *Canalisporium*

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The genus *Neopaxillus* (Crepidotaceae)ROY WATLING^{*1} & M. CATHERINE AIME²¹ Caledonia Mycological Enterprises, Edinburgh EH4 3HU UK² Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, 47901 USA* CORRESPONDENCE TO: caledonianmyc@blueyonder.co.uk

ABSTRACT — *Neopaxillus* (Agaricomycotina, Basidiomycota) was formerly placed in the Paxillaceae (Boletales) by Singer. Herein we provide additional evidence that the genus is referable to the Crepidotaceae (Agaricales) and a redescription of *N. echinospermus* from recently collected material.

KEY WORDS — fungal systematics, *Melanomphalia*, neotropical fungi, *Paxillus*, *Simocybe*

Introduction

Neopaxillus Singer (1948) was erected as a monotypic genus, typified by *N. echinosporus*. The description was based on a collection by J. Rick from sandy soil in Southern Brazil that is deposited in the Farlow Herbarium, Massachusetts, USA. *Neopaxillus* was characterized as being morphologically intermediate between the Cortinariaceae (Agaricales) and the Paxillaceae (Boletales). The habit and trama were likened to that of the Paxillaceae in having a clitocyboid-omphalinoid facies reminiscent of a small *Phylloporus rhodoxanthus* (Schwein.) Bres. (Boletaceae) or *Paxillus* species. The basidiospores, however, were described as having characters more reminiscent of *Cortinarius*, although their ornamentation was not identical to that of any known *Cortinarius* species (Singer 1948).

Soon after his 1948 publication, Singer (1951) determined that *Neopaxillus echinosporus* was in fact conspecific with the Argentine *Naucoria echinosperma* (Spegazzini 1889), which he recombined as *Neopaxillus echinospermus*. Because this name has priority, *Neopaxillus echinospermus* is the correct name for the combined taxon; however, the genus *Neopaxillus* remains typified by *N. echinosporus*. In later works, Singer included two other South American species, *Flammula echinospora* (Spegazzini 1902) and *Flammula papillosispora* (Spegazzini 1919), in the synonymy of *Neopaxillus echinospermus* (Singer 1952, 1964; Singer et al. 1990).

Singer (1948) likened *Neopaxillus echinosporus* in size to *Deconica crobula* (Fr.) Romagn., with which Rick apparently confused his collection. One distinguishing feature was the ornamented spores, which Singer regarded as a link to *Ripartites* P. Karst., a genus also then placed in the *Paxillaceae*. Their ornamented basidiospores separated both genera from all the other taxa that Singer accepted in the *Paxillaceae* (Singer 1990). *Neopaxillus* is separable from *Ripartites* by its larger basidiospores, lamellae that anastomose towards the stipe, and an almost continuous trichodermial pileipellis composed of chains of hyphae with broadly clavate terminal cells. Furthermore, according to Singer (1948), the hymenophoral trama in *Neopaxillus* is not characteristically divergent but rather weakly or vaguely bilateral in immature specimens.

It has more recently become apparent that *Paxillaceae* sensu Singer (1986) is an artificial family with many disparate constituent elements, e.g. *Omphalotus* Fayod (now placed in the *Marasmiaceae*; Kirk et al. 2008), *Hygrophoropsis* (J. Schröt.) Maire ex Martin-Sans (now placed in the *Hygrophoropsidaceae*; Kirk et al. 2008), and *Phyllobolites* Singer (now placed in the *Boletaceae*; Kirk et al. 2008). The genus *Paxillus* sensu Singer itself has been subdivided with saprobic species [e.g., *Paxillus panuoides* (Fr.) Fr.] now placed in *Tapinella* E.-J. Gilbert (*Tapinellaceae*), southern hemisphere species now in *Austropaxillus* Bresinsky & Jarosch (*Serpulaceae*), and the ectomycorrhizal members remaining in *Paxillus* (Kirk et al. 2008, Watling 2008).

Ripartites, which has been placed in several agaric families, including the *Tricholomataceae* where it is presently placed, was linked to *Neopaxillus* by general appearance, with the pair placed in proximity to *Paxillus* by virtue of the open-pored hilum of the basidiospore. Results from numerical analyses conducted by Machol & Singer (1971) supported this placement. However, in his review of the boletes and their relatives, Watling (2008) deemed it necessary to reexamine *Neopaxillus*, which became possible with collection of new material in the Atlantic rainforests of Brazil by André de Meijer. Watling's initial examination of this material indicated a possible link to the *Crepidotaceae* due to the echinulate basidiospores reminiscent of similar ornamentation seen in some *Crepidotus* taxa. This observation led us to attempt to infer the true position of *Neopaxillus* within the *Agaricomycotina* using DNA sequence analyses.

Materials & methods

Collections examined

New collections of *N. echinospermus* were made by André de Meijer on forest humus in the Mata Atlântica in Paraná, Brazil. Material is deposited in the Royal Botanic Garden, Edinburgh, Scotland, UK (E). The field colors were matched to Methuen's Handbook (Kornerup & Wanscher 1978). Microscopic characters were observed using a Leitz Ortholux microscope and examined in a 10% aqueous ammonia solution.

25 spores of each collection in five separate mounts were measured; Melzer's reagent (a mixture of chloral hydrate, potassium iodide and elemental iodine) and cotton blue in lactophenol supplemented the observations; material examined using a Jeol T200 scanning electron microscope were suspended first in the above ammonia solution before applying to the stub, drying, and coating with gold.

Molecular analyses

DNA was extracted from dried tissue from the two herbarium *Neopaxillus echinospermus* specimens with the UltraClean Plant DNA Isolation Kit (MoBio Laboratories, Inc., Solana Beach, CA) following the manufacturer's instructions. Primers LSU4-B (Aime & Phillips-Mora 2005) and LR6 (Moncalvo et al. 1995) were used to amplify and sequence the first ~1200 bp of the 28S ribosomal DNA using previously described parameters (Aime & Phillips-Mora 2005). Preliminary phylogenetic analysis was conducted by analyzing LSU sequences of *N. echinospermus* within the 877 taxa dataset of Moncalvo et al. (2002). This dataset contains representatives of all major agaricalean lineages, as well as exemplar taxa from the other major *Agaricomycotina* clades, including *Boletales*, with *Auricularia polytricha* (*Auriculariales*) as the outgroup (Moncalvo et al. 2002). Based on the results of the preliminary analyses (not shown) a new dataset was constructed with additional sampling from within the *Crepidotaceae*, to which *N. echinospermus* showed affinity. A total of 21 species were chosen including the type species of *Crepidotus* [*C. mollis* (Schaeff.) Staude] and *Simocybe* [type, *S. centunculus* (Fr.) P. Karst.] from previously published *Crepidotaceae* sequences (Aime & Miller 2002, Aime et al. 2002, Aime et al. 2005, Aime et al. 2009, Matheny 2005, Moncalvo et al. 2002, and unpublished), exemplar sequences from the genus *Inocybe* (Matheny 2005, Moncalvo et al. 2002, Ryberg et al. 2008, and unpublished), which has been suggested as the sister family to the *Crepidotaceae* sensu Aime (Matheny et al. 2006), with *Agaricus* aff. *campestris* and *Deconica montana* (= *Psilocybe montana*) (Matheny et al. 2006, and unpublished) selected as outgroups.

New sequences were edited and assembled in Sequencher v4.1.4 (Gene Codes Corp., Ann Arbor, MI) and aligned visually in Se-Al v2.0a11 (Andrew Rambaut, Dept. Zoology, University of Oxford, U.K.; <http://evolve.zoo.ox.ac.uk/>) over a total of 1074 bp. Maximum likelihood (ML) analyses were conducted in RAXML-HPC2 v. 7.2.7 (Stamatakis 2006) via the CIPRES portal (Miller et al. 2011) using default parameters and 1000 bootstrapping replicates. Maximum parsimony (MP) analyses were conducted in Paup* v4.0b10 (Swofford 2002) as heuristic searches with 1000 random addition replicates and TBR branch swapping; bootstrap analysis consisted of 1000 MP replicates. Sequences have been deposited in GenBank as JQ404442 (AM 1424) and JQ404443 (AM 1690).

Results

Based on prior molecular studies, the members of *Paxillaceae* sensu Singer have been segregated into three groups, the *Paxillineae*, *Serpulaceae* (*Coniophorineae*), and *Tapinellineae*, all of which belong to the *Boletales* (Binder & Hibbett 2006). Preliminary results from 28S analyses of *Neopaxillus echinospermus* within an inclusive dataset of *Agaricomycotina* placed

N. echinospermus firmly within the *Crepidotaceae*, with no affinity to the *Boletales* (data not shown). A second dataset was constructed with exemplars from all *Crepidotaceae* genera and representative outgroups (Fig. 1), strongly supporting the placement of *N. echinospermus* within the *Crepidotaceae*. The 28S locus, alone, did not provide strong support separating the three genera (*Crepidotus*, *Simocybe*, and *Neopaxillus*), although each forms a monophyletic clade within *Crepidotaceae* under all searching algorithms used, with *Neopaxillus* consistently resolved as the sister lineage to *Crepidotus*.

Taxonomy

Neopaxillus echinospermus (Speg.) Singer, Lilloa 22: 633. 1951 ["1949"].

≡ *Naucoria echinosperma* Speg., Bol. Acad. Nac. Cienc. Cordoba 11: 424. 1889.

= *Flammula echinospora* Speg., An. Mus. Nac. B.Aires 8: 51. 1902.

= *Flammula papilloispora* Speg., Bol. Acad. Nac. Cienc. Cordoba 23:396. 1919.

= *Neopaxillus echinosporus* Singer, Mycologia 40: 262. 1948.

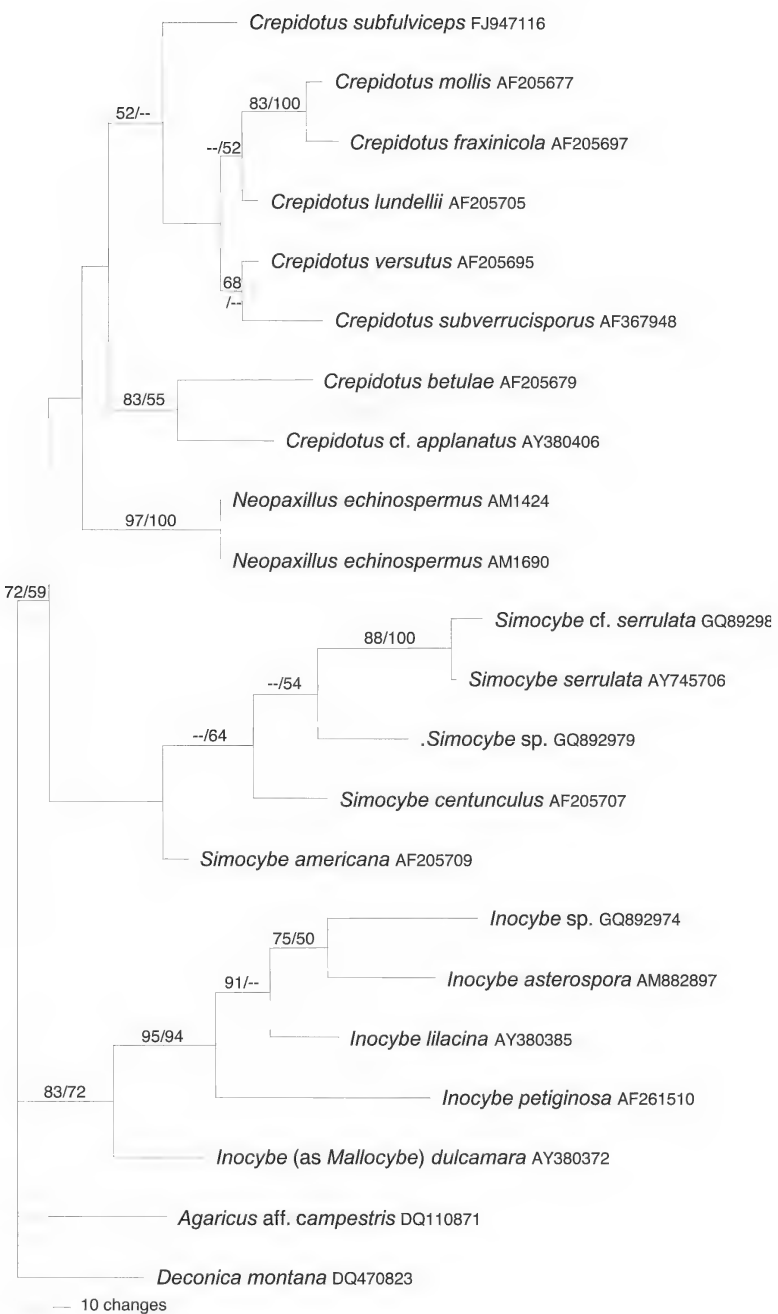
PILEUS 12–40 mm broad, center depressed even in youth, slightly hygrophanous, non-striate when fresh, golden brown, brownish orange when dry, smooth, dry, glabrous; margin often decurved, sometimes undulate. LAMELLAE strongly decurrent, distant, margin straight or concave, 5.5 mm broad, clay-brown at first, dark brown when fully mature, neither interveined, nor forked. STIPE 17–40 × 3.5–7 mm, cylindrical or slightly attenuated downwards, solid, paler and more yellow than pileus, minutely innately brown-striate, smooth, dry; basal mycelium white. Context in pileus when fresh yellowish brown, drying pale ochraceous to white; in stipe drying white, but in stipe base often becoming brown; odor fungoid or none.

BASIDIOSPORES 7–8(–8.5) µm subglobose, strongly warty-echinulate, ornaments <0.7 µm high, inamyloid. CHEILO- & PLEUROCYSTIDIA absent. PILEIPELLIS composed of irregularly arranged, rarely encrusted hyphae 5–7 µm broad. CLAMP-CONNECTIONS absent.

MATERIAL EXAMINED: BRAZIL, Paraná, General Caneiro, in forest humus, 20 xii 1989, Meijer 1424 (E); 12 v 1990, Meijer 1690 (E).

NOTES: There is some confusion as to where João Rick collected his material, which Watling & de Meijer (1997) have addressed. This fungus has been previously illustrated (e.g., de Meijer 2008, fruiting body; Watling & de Meijer 1997, basidiospores) and described in detail (e.g., Singer 1948, 1952, Watling & de Meijer 1997).

FIG. 1. Phylogenetic tree based on maximum parsimony (MP) analyses of 28S ribosomal DNA sequences of two isolates of *Neopaxillus echinospermus* with representative crepidotaceous and inocybaceous taxa. *Agaricus* aff. *campestris* and *Deconica montana* chosen as outgroups. Support at nodes shown as MP bootstrapping/maximum likelihood bootstrapping values.



Discussion

Previous work showed the *Crepidotaceae* to consist of two saprobic agaricoid genera — the predominantly pleurotoid genus *Crepidotus* (Fr.) Staude and *Simocybe* P. Karst. (which contains both pleurotoid and centrally stipitate forms; Aime et al. 2005) — and several cyphelloid genera (Singer 1986, Bodensteiner et al. 2004). Our results support the findings of Vizzini et al. (2012) in placing *Neopaxillus* as a sister genus to *Crepidotus*. However, that study was inconclusive in its treatment of *Simocybe*, whereas the latter is supported within *Crepidotaceae* in our analyses. The inclusion of *Neopaxillus* expands the familial concept to include a genus composed entirely of centrally stipitate, terrestrial species with unknown ecology. Although some species of *Crepidotus* and *Simocybe* can be found on bare or moss-covered soil, they generally fruit on well decomposed large diameter logs, as well as fallen branches and sometimes herbaceous and twiggy material. One question that has not been resolved is whether *Neopaxillus* is ectomycorrhizal, although its present affinities would not suggest this life-strategy, and at least one other species (i.e., *N. plumbeus* Singer & Lodge) was not collected near any ectomycorrhizal host trees (D. Jean Lodge, pers. comm.). However, the sister-relationship between *Crepidotaceae* and the ectomycorrhizal *Inocybaceae* (Matheny et al. 2006) admits the possibility that *Neopaxillus* is also ectomycorrhizal. A placement in *Paxillaceae* might have hinted at an ectomycorrhizal role, although in the sense of Singer (1951) this family contained both saprobes and ectomycorrhizal associates. Singer (1952) wrote “on the ground in woods accompanying rivers usually in small groups but never densely clustered.” Our present collections are from the Atlantic rainforest in mixed ombrophilous forest with *Araucaria angustifolia* at 800–900 m above sea level, which basically agrees with Singer’s observation for Argentina. He also noted, “fruiting in summer and fall.” Watling & de Meijer (1997) indicated that de Meijer’s collections occurred between December (summer) and May (fall) in Brazil.

A hint to the relationship of *Neopaxillus* and the *Crepidotaceae* may be sought in the observations of Singer, who noted “an actual affinity between *Neopaxillus* and *Tubaria* section *Thermophila*, but even so, they are not congeneric, but can be put into the same family” (Singer 1951). Indeed, *Tubaria thermophila* has subsequently been shown to belong to *Crepidotaceae*, along with several other stipitate species formerly placed in *Melanomphalia* M.P. Christ. (Aime et al. 2002, 2005, 2009). This refuted Christiansen’s suggestion that *Melanomphalia* might be related to the *Gomphidiaceae* (Christiansen 1936), which, like *Paxillaceae*, is now also placed within *Boletales*. Horak (1980) also hinted at a relationship between *Neopaxillus* and *Crepidotus* in his descriptions of *N. bryogenus* E. Horak and *C. velutinoaffinis* Singer, both agarics from South America, although spore ornamentation is very different between the former

and the majority of *Crepidotus* spp. Indeed the illustrations in Horak (1980) for both species resemble those depicted for *Melanomphalia inocyboides* Singer and *M. viscosa* Singer, respectively, which leaves one to suspect that *N. bryogenus* may not be assignable to *Neopaxillus* based on the type species. Three additional *Neopaxillus* species are known: *N. plumbeus* from Puerto Rico (Singer & Lodge 1989), *N. reticulatus* (Petch) Pegler from Sri Lanka (Pegler 1986), and *N. dominicanus* Angilini & Vizzini from the Dominican Republic and Mexico.

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New records of *Aspicilia* species from China

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ABSTRACT — As a result from our studies on the lichenized ascomycete genus *Aspicilia*, the species *A. persica*, *A. verrucigera*, and *A. subdepressa* are reported for the first time from China.

KEY WORDS — lichen, taxonomy

Introduction

Aspicilia A. Massal. (Megasporaceae, Pertusariales, Ascomycota), a lichen genus with worldwide distribution, includes over 200 species (Kirk et al. 2008). Forty-one species have previously been reported from China (Wei 1991, Abbas & Wu 1998, Sohrabi et al. 2010a). Our recent studies on *Aspicilia* establish that three additional species occur in China: *A. persica*, *A. verrucigera*, and *A. subdepressa*.

Materials & methods

The specimens studied are preserved in SDNU (Lichen Section of the Botanical Herbarium, Shandong Normal University). Specimen morphology and anatomy were examined using a dissecting microscope (Olympus SZ51) and a compact light microscope (Olympus CX41). The lichen substances were detected by standardized thin layer chromatography techniques (TLC) with solvent C (Orange et al. 2010). Photos of the morphology were taken with an Olympus SZX16 stereomicroscope and of the anatomy with an Olympus BX61 compound microscope with DP72.

New records

Aspicilia persica (Müll. Arg.) Sohrabi, Sauteria 15: 467. 2008.

FIG. 1

THALLUS crustose, rimose to areolate, $\pm$ orbicular, subradiate, 2–5.5(–7) cm in diam., $\pm$ 0.5 mm thick; areoles angular to irregular, 0.7–1.2(–1.5) mm in diam., convex, continuous, fissured, cracks lighter towards the thallus edge;

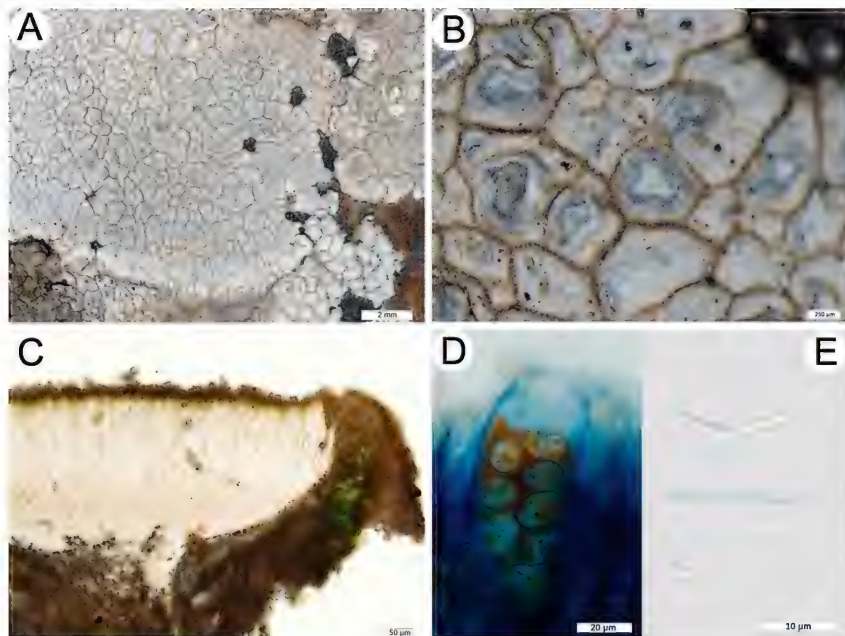


FIGURE 1. *Aspicilia persica* (Z.L. Huang 20106405). A. Habitus; B. Apothecia; C. Apothecial anatomy; D. Ascus and ascospores after I treatment; E. Conidia. Scale bars: A = 2 mm; B = 250 µm; C = 50 µm; D = 20 µm; E = 10 µm.

prothallus sometimes present, black. UPPER SURFACE white-gray to white, matt, densely pruinose. APOTHECIA prominent, aspicilioid, usually solitary in the areoles, 0.3–0.9 mm in diam.; thalline margin prominent, usually forming a black rim, or sometimes somewhat paler due to the dense pruina; DISC black, with dense white pruina; EPITHECIUM olive-green to olive-brown, K+ brown, N+ green; HYMENIUM hyaline, I+ blue, 125–167.5 µm high; PARAPHYSES separating in KOH, moniliform; SUBHYMENIUM and HYPOTHECIUM colorless, I+ blue, together 62.5–87.5 µm thick, without algae below the hypothecium; ASCI clavate, *Aspicilia*-type, 8-spored; ASCOSPORES hyaline, simple, ellipsoid, 17.5–22.5×13–15 µm; CONIDIA filiform, 15–25×0.8–1 µm.

SPOT TESTS — Medulla K+ yellow, C–, I–, P+ orange.

SECONDARY METABOLITES — Stictic acid (major), norstictic acid (minor).

SPECIMENS EXAMINED — CHINA. XINJIANG. URUMQI CITY, Mt. Tianshan, Glacier No.1, alt. 3800 m, on siliceous rock, 27 Aug. 2011, Z.L. Huang 20106405 (SDNU); L. Li 20125895 (SDNU).

COMMENTS — *Aspicilia persica* is characterized by convex areoles, medium-sized ascospores, prominent thalline margins, and black disks covered by dense white pruina. *Aspicilia boykinii* Owe-Larss. & A. Nordin, which also has a white

or gray-white thallus and prominent thalline margins, looks like *A. persica* but differs in its smaller spores, thin thalline margin, flat or (sometimes) convex areoles, and white or gray apothecial rims. *Aspicilia candida* (Anzi) Hue, another species with white upper surface, differs from *A. persica* by having a rather low (75–85 μm) hymenium and submoniliform paraphyses. *Circinaria calcarea*, a subradiate and calciferous species with white thalli, also resembles *A. persica* but has 4-spored asci, shorter conidia, and a K– thallus.

Aspicilia persica is a saxicolous species, known previously only from Iran (Szatala 1957, Seaward et al. 2004, Sohrabi et al. 2010b).

Aspicilia verrucigera Hue, Nouv. Arch. Mus. Hist. Nat., 5 Sér., 2: 48. 1912. FIG. 2

THALLUS crustose, distinctly verrucose-areolate in the center, sometimes rimose at the edge, 2–5 cm in diam., $\pm$ 0.5 mm thick; AREOLES angular to irregular, 0.5–1 mm in diam., contiguous, convex, rough; UPPER SURFACE gray to gray-brown, matt or somewhat shiny; prothallus present, black to brown-black, 0.1–0.5 mm wide. APOTHECIA 0.2–0.5(–0.7) mm in diam., aspicilioid, 1–3 per areole, round or angular; thalline margin thin, slightly raised, concolorous with the thallus, sometimes forming a white rim when young;

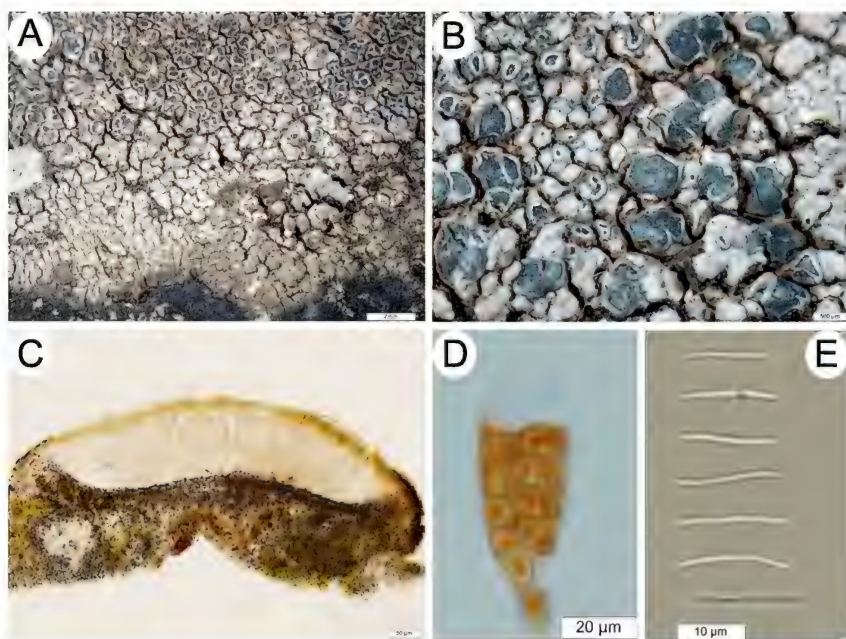


FIGURE 2. *Aspicilia verrucigera* (J.Z. Zhao 20050703-9). A. Habitus; B. Apothecia; C. Apothecial anatomy; D. Ascus and ascospores after I treatment; E. Conidia. Scale bars: A = 2 mm; B = 500 μm ; C = 50 μm ; D = 20 μm ; E = 10 μm .

DISC black, bare or with slight pruina; EPITHECIUM olive-green to olive-brown, K+ brown, N+ green; HYMENIUM hyaline, I+ blue to green-blue, 87.5–125 μm high; PARAPHYSES separating in KOH, moniliform; SUBHYMENIUM and HYPOTHECIUM colorless, I+ blue, together 37.5–50 μm thick, without algae below the hypothecium. ASCI clavate, 8-spored, *Aspicilia*-type; ASCOSPORES hyaline, simple, ellipsoid, 12.5–17.5 $\times$ 7.5–10 μm ; CONIDIA filiform, 15–22.5 $\times$ 0.8–1 μm .

SPOT TESTS — Medulla K+ yellow, C–, I–, P+ orange.

SECONDARY METABOLITES — Stictic acid (major), norstictic acid (minor).

SPECIMENS EXAMINED — CHINA. XINJIANG, KANASI, alt. 1350 m, on siliceous rock, 3 Jul. 2005, J.Z. Zhao 20050703-9 (SDNU); QINGHAI, MENYUAN COUNTY, Fengxiakou, alt. 3300 m, on siliceous rock, 3 Aug. 2007, Y.D. Du 20070248 (SDNU).

COMMENTS — *Aspicilia verrucigera* is characterized by its numerous small apothecia and the presence of stictic acid. Morphologically, this species is easily confused with *Aspicilia cinerea* (L.) Körb., which has a gray K+ red thallus and norstictic acid as major metabolite. *Circinaria caesiocinerea*, which is similar to *A. verrucigera* in thallus color and thalline margin, differs by its larger spores, short conidia, and the presence of aspicilin. *Aspicilia dudinensis* (H. Magn.) Oxner also resembles *A. verrucigera* in its verrucose or prominent areoles but is easily separated by the K+ orange thallus reaction, a different exciple color, and smaller spores.

Aspicilia verrucigera is distributed on siliceous rocks from sea level to the mountains and has been reported from Europe (Magnusson 1939) and North America (Owe-Larsson et al. 2007).

Aspicilia subdepressa (Nyl.) Arnold, Verh. Ges. Wien 19: 611. 1869.

FIG. 3

THALLUS crustose, rimose, areolate, areoles 0.2–1.2 mm in diam., $\pm$ 0.3 mm thick, angular to irregular, or sometimes round, contiguous, smooth, somewhat convex, indistinctly lobed, and the edge of the areoles is often slightly lifted upward; UPPER SURFACE gray to green-gray, sometimes brownish gray, matt; prothallus absent. APOTHECIA 0.3–0.7 mm in diam., aspicilioid, ordinarily solitary, or 2 per areole; DISC brown or black, not pruinose; thalline margin prominent when old, concolorous with the thallus; EPITHECIUM brown or olive-brown, K+ brown, N+ green; HYMENIUM hyaline, colorless, 100–150 μm high, I+ blue; PARAPHYSES submoniliform to moniliform, separating in KOH; SUBHYMENIUM and HYPOTHECIUM colorless, I+ blue, together 25–37.5(–50) μm thick, with algae below the hypothecium. ASCI clavate, 8-spored, *Aspicilia*-type; ASCOSPORES hyaline, simple, ellipsoid, (12.5–)15–20(–22.5) $\times$ (7.5–)10–12.5(–15) μm , CONIDIA filiform, straight or slightly curved, 7.5–12 $\times$ 0.8–1 μm .

SPOT TESTS — Medulla K+ yellow, C–, I–, P+ orange.

SECONDARY METABOLITES — Stictic acid.

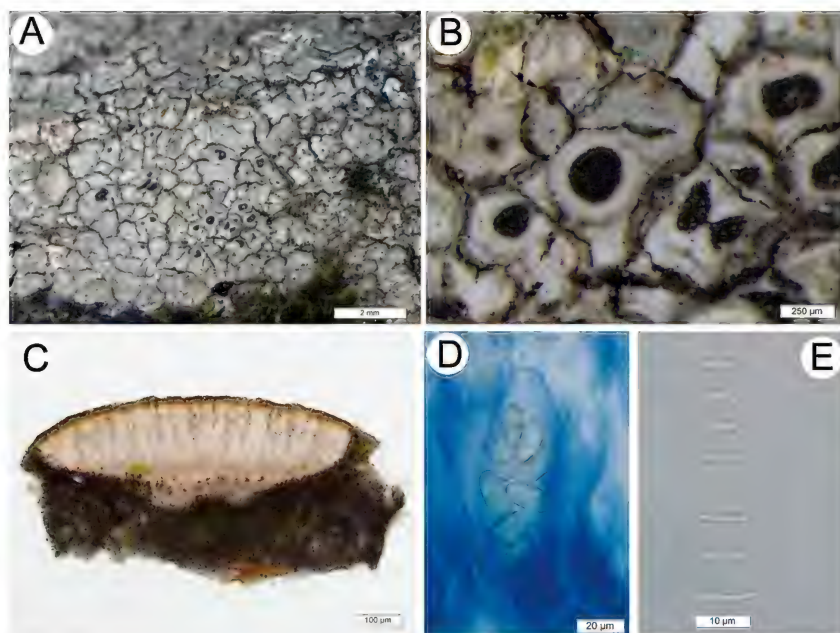


FIGURE 3. *Aspicilia subdepressa* (Q. Ren 2011304). A. Habitus; B. Apothecia; C. Apothecial anatomy; D. Ascus and ascospores after I treatment; E. Conidia. Scale bars: A = 2 mm; B = 250 µm; C = 100 µm; D = 20 µm; E = 10 µm.

SPECIMEN EXAMINED — CHINA. HEILONGJIANG. WUDALIANCHI CITY, Wudalianchi, Shihai, alt. 4400 m, on rock, 14 Jul. 2011, Q. Ren 2011304 (SDNU).

COMMENTS — *Aspicilia subdepressa* is characterized by its smooth grayish thallus, short conidia, and the presence of stictic acid. *Aspicilia cupulifera* (H. Magn.) Oxner is morphologically similar to *A. subdepressa* but has a K+ nebulous yellow exciple, intensely branched paraphyses, and a lower hymenium. *Aspicilia proluta* (Nyl.) Hue has several features in common with *A. subdepressa*, such as a smooth thallus, short conidia, and the same major metabolite, but it is distinguished by its gray or bluish thallus, different habitat, and lack of prominent thalline margin.

Aspicilia subdepressa has been reported from France, from Pyrénées-Orientales (Roux et al. 2011) and Massif Central (Magnusson 1939), where it grows on rocks.

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MYCOTAXON

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Ambomucor gen. & spp. nov. from China

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ABSTRACT — *Ambomucor* is described as a new genus containing *A. seriatoinflatus* sp. nov. (type), *A. seriatoinflatus* var. *brevior* var. nov., and *A. clavatus* sp. nov. Morphological characteristics for recognizing and differentiating these new taxa are discussed, and full descriptions, line drawings, and a key to taxa are provided.

KEYWORDS — taxonomy, morphology, *Mucorales*, new species, new variety

Introduction

In the summer of 2003, an interesting mucoraceous fungus was isolated from a soil sample collected in Inner Mongolia. Morphological examination revealed the fungus to represent a new species *Ambomucor seriatoinflatus*, described here as the type species of a new genus, *Ambomucor*. One month later, a second strain of this new genus was isolated from Xinjiang Province and is described here as a new variety of the type species, *A. seriatoinflatus* var. *brevior*. In addition, a fungus from Inner Mongolia, originally identified as *Zygorhynchus moelleri* Vuill., is described here as new species, *A. clavatus*. Since then, another new species (from a dung sample collected in Tibet) and another new variety of *A. seriatoinflatus* (eleven strains from Tibet, and one from Shaanxi Province) have been found by the second author, to be described elsewhere.

Materials & methods**Isolations**

Fungi were isolated from soil samples using the soil plate method of Warcup (1950).

Cultures

Living cultures of the three taxa studied are preserved in the Culture Collection of the State Key Laboratory of Mycology (with an “Am-” prefix) and the China General

Microbiological Culture Collection Center (with a “CGMCC-” prefix). Dried cultures of the type strains are deposited in the Herbarium Mycologicum Academiae Sinicae (HMAS). These culture collections and herbarium all belong to the Institute of Microbiology, Chinese Academy of Sciences, Beijing, China.

Media & cultivation

Modified SMA (Hesseltine's modified synthetic *Mucor* agar: dextrose 20 g, asparagine 2 g, KH_2PO_4 0.5 g, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 0.25 g, thiamine chloride 0.5 mg, agar 20 g in 1000 mL distilled water, pH 7; Hesseltine & Ellis 1973) and PDA adjusted to pH 7 were used for morphological studies. PDA adjusted to pH 7 was also used for establishing temperature-growth relationships and for mating experiments. Cultivation period and temperature were (i) 5–7(–10) days at 18–20°C for morphological studies; (ii) 4–7 days at 25–37°C for determining the temperature maximum; and (iii) 7–14 days at 18–25°C for mating experiments.

Results

Maximum growth temperature

The three *Ambomucor* strains described in this paper were tested twice for their maximum growth temperature. The maximum growth temperatures of both *A. seriatoinflatus* var. *seriatoinflatus* and *A. seriatoinflatus* var. *brevior* are 30°C and that of *A. clavatus* is 33°C. As shown by our studies on *Cunninghamella* (Zheng & Chen 2001) and *Rhizopus* (Zheng et al. 2007), different varieties of the same species have a similar maximum growth temperature, while different species have different ranges of maximum growth temperature.

Mating experiments

The 16 living cultures of *Ambomucor* were crossed in all combinations, but zygospores were not produced.

Morphological studies

Within the *Mucorales*, the new genus is morphologically unique in producing two kinds of sporangia (fertile and non-fertile) on the same or different sporangiophores. The fertile sporangia are multispored and columellate, similar to those in the *Mucoraceae*. Aborted sporangia, which occur in short to long chains, are vesicle-like, produce no spores, and lack a columella.

Taxonomy

Ambomucor is distinguished from all other genera of the *Mucorales* (Alexopoulos et al. 1996, von Arx 1982, Benny & Benjamin 1991, Hesseltine 1955, Hesseltine & Ellis 1973, Tai 1979) in having simultaneously two kinds of sporangia: fertile and aborted. We include *Ambomucor* in the *Mucoraceae* based mainly on the characteristics of the fertile sporangia as well as its close relationship with the genus *Zygorhynchus*, also in *Mucoraceae*.

Characteristics for dividing species or varieties in *Ambomucor* include 1) growing or not growing above 30°C, 2) sporangiophore branching patterns, 3) sporangial

size and shape, 4) number of aborted sporangia in a chain, 5) presence or absence, place of origination, and sterile outgrowths that may or may not be spirally twisted from the sporangiophores bearing aborted sporangia, 6) size and shape of the columellae in the fertile sporangia, 7) sporangiospore size and shape, and 8) chlamydospore presence or absence.

***Ambomucor* R.Y. Zheng & X.Y. Liu, gen. nov.**

MYCOBANK MB 518101

Differs from all known genera in the *Mucorales* by possessing both fertile and aborted sporangia simultaneously on the same or different sporangiophores.

TYPE SPECIES: *Ambomucor seriatoinflatus* R.Y. Zheng & X.Y. Liu

ETYMOLOGY: *Ambomucor*, referring to the presence of two kinds of sporangia.

MYCELIA branching, nonseptate when young, septate in age, with aerial hyphae. STOLONS absent. RHIZOIDS scanty, simple or branched, not opposite sporangiophores. SPORANGIOPHORES arising directly from substrate mycelia or from aerial hyphae, simple or more usually branched, of 3 main types: (1) bearing normal fertile sporangia only, (2) bearing aborted sporangia only, (3) bearing both fertile and aborted sporangia on the same sporangiophore. ABORTED SPORANGIA either borne terminally on the main axes or branches of the sporangiophores or repeatedly proliferating terminally or laterally many times, transferring their contents forward to form chains of aborted sporangia until a fertile sporangium is formed. FERTILE SPORANGIA borne terminally on the main axes or branches of the sporangiophores, globose to somewhat depressed-globose, non-apophysate, breaking or deliquescing, dark brown after mature. COLUMELLAE well developed but only in fertile sporangia. SPORANGIOSPORES also forming only in fertile sporangia. CHLAMYDOSPORES present. ZYGOSPORES unknown.

***Ambomucor seriatoinflatus* R.Y. Zheng & X.Y. Liu, sp. nov.**

FIGS 1, 2

MYCOBANK MB 518102

Differs from all known species of *Mucorales* by simultaneously possessing both fertile and aborted sporangia on the same or different sporangiophores.

TYPE: People's Republic of China. Inner Mongolia, Taipusiqi, 41.934593°N 115.282116°E, soil, 16 July 2003, Xiao-yong Liu (Holotype HMAS 84258—1; ex-holotype culture CGMCC 3.6665 = Am-1; GenBank AY743664. Isotypes HMAS 84258—2–8).

ETYMOLOGY: *seriatoinflatus*, referring to the chains of aborted sporangia.

COLONIES on SMA and PDA at first subfloccose, then granulate, filling the Petri dish in 6–7 (SMA) or 5–6 (PDA) days at 18°C, about 1–3 mm high, at first white, then 'Drab Gray' to 'Light Gray' (Ridgway XLVI), reverse cream to light yellowish brown. HYPHAE branching, nonseptate when young, septate

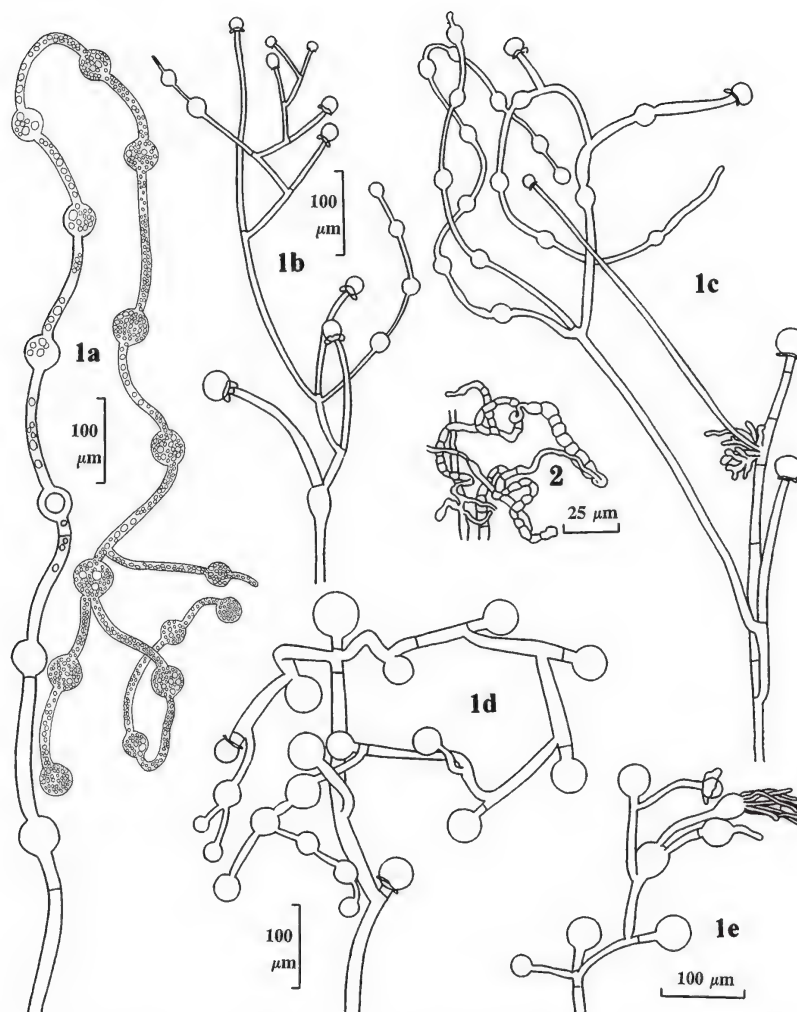


FIGURE 1. *Ambomucor seriatoinflatus* var. *seriatoinflatus* (AS 3.6665, = Am-1, ex-holotype). 1. Upper portions of sporangiophores showing various kinds of constructions: (a) a long chain of aborted sporangia with intercalary sporangiophores formed between two aborted sporangia; (b) both fertile and aborted sporangia are formed on the same sporangiophore, note that the aborted sporangia are in short chains; (c) same as (b) except that the aborted sporangial chains are longer, also that rhizoids are formed at the base of a sporangial branch; (d) similar to (b) and (c) by forming both fertile and aborted sporangia on the same sporangiophore except that aborted sporangia are much more abundant than the fertile sporangium and the sporangiophore branches usually do not originated from the tip of the former aborted sporangium; (e) a branched sporangiophore similar to (b), (c), and (d) by forming both fertile and aborted sporangia on the same sporangiophore except that rhizoids are formed at the apex of one of the aborted sporangia. 2. Chlamydospores formed on the substrate mycelium.

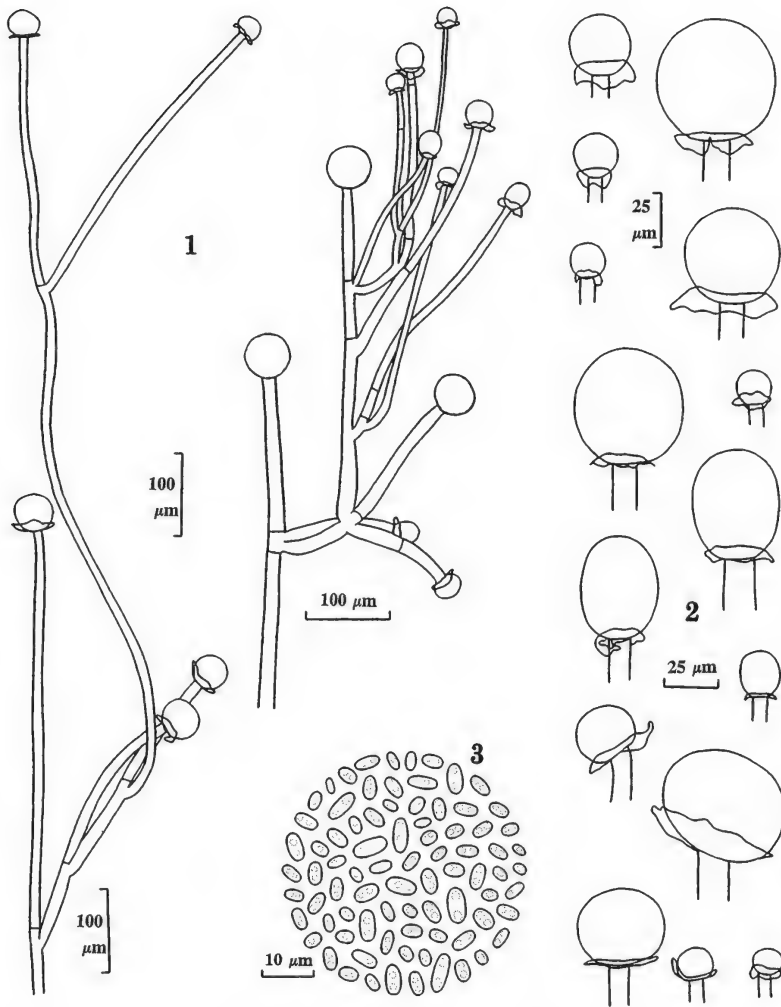


FIGURE 2. *Ambomucor seriatoinflatus* var. *seriatoinflatus* (AS 3.6665, = Am-1, ex-holotype). 1. Upper portions of sporangiophores, with fertile sporangia only. 2. Columellae of various shapes, all with a small collar. 3. Sporangiospores.

in age, (1.5–)7–14(–18.5) μm diam. STOLONS absent. RHIZOIDS scanty, not opposite sporangiophores; arising from various parts of the sporangiophores or the aborted sporangia. SPORANGIOPHORES erect or recumbent, arising directly from substrate or aerial hyphae, of 3 main types: (1) bearing only

normal fertile sporangia, (2) bearing only aborted sporangia, (3) bearing both fertile and aborted sporangia on the same sporangiophore; main axes of the sporangiophores rarely simple, usually branched, 9–18.5(–22) μm diam.; primary branches 1–4(–10), single, in pairs, remaining simple, more often branching monopodially or pseudo-verticillately, sometimes zigzag and branching up to 7 times, (35–)98–437(–1000) μm long, 4.5–13(–18) μm diam., rarely subcurved, usually equal or subequal in width throughout, sometimes slightly subequal in width throughout, sometimes slightly narrowed just beneath the terminal sporangia, hyaline to pale greenish brown, with or without granular contents, becoming vacuolated in age. SEPTA in main axes and branches of the sporangiophores usually present at the place of branching, sometimes without definite position. ABORTED SPORANGIA may also form terminally on the main axes and branches of sporangiophores, or may repeatedly proliferate terminally or laterally, forming intercalary sporangiophores between two aborted sporangia up to 20 times or more, transferring their contents forward to form a short or long chain of aborted sporangia until formation of a fertile and normal sporangium, globose and (18.5–)32–69 μm diam., or slightly elongate when proliferated, granular when young, vacuolate in age, subhyaline. FERTILE SPORANGIA borne terminally on the main axes or branches of the sporangiophores, globose, (14–)26–64(–88) μm diam.; non-apophysate, breaking or slowly dissolving, thin-walled, dark brown when mature, broken pieces of wall pale grayish brown. COLUMELLAE formed only in fertile sporangia, well developed, very regular in shape, larger ones mostly globose and 16–51(–60) μm diam., or ovoid to ellipsoid-ovoid and (21–)37–55 $\times$ (19–)32–48.5 μm diam., smaller ones depressed-globose to sub-applanate and 11.5–51 $\times$ 15–64.5 μm , hyaline, some with grayish to brownish contents, smooth, regularly with a distinct collar. SPORANGIOSPORES forming only in fertile sporangia, ellipsoid to oblong-ellipsoid, (2.5–)3.5–7 $\times$ (1.5–)2–2.5(–3.5) μm , (1–)2 guttulate, hyaline, grayish in mass, smooth, becoming vacuolated in old cultures. STERILE OUTGROWTHS usually absent. CHLAMYDOSPORES rare, single, in short chains, or in small masses, subglobose, ovoid or irregular, 5–9 $\times$ 4–7 μm , hyaline to yellow. ZYGOSPORES unknown.

Ambomucor seriatoinflatus* var. *brevior R.Y. Zheng & X.Y. Liu, var. nov. FIGS 3, 4
MYCOBANK MB 518103

Differs from *Ambomucor seriatoinflatus* var. *seriatoinflatus* by its shorter sporangiospores that in turn have much shorter, curved, verticillate branches.

TYPE: People's Republic of China. Xinjiang, a glacial valley, 43.648994°N 85.117264°E, soil, 3 August 2001, Xing-zhong Liu (Holotype HMAS 89521–1; ex-holotype culture CGMCC 3.6784 = Am-2; GenBank KC108739. Isotypes HMAS 89521–2–8).

ETYMOLOGY: *brevior*, referring to the shorter sporangiospores.

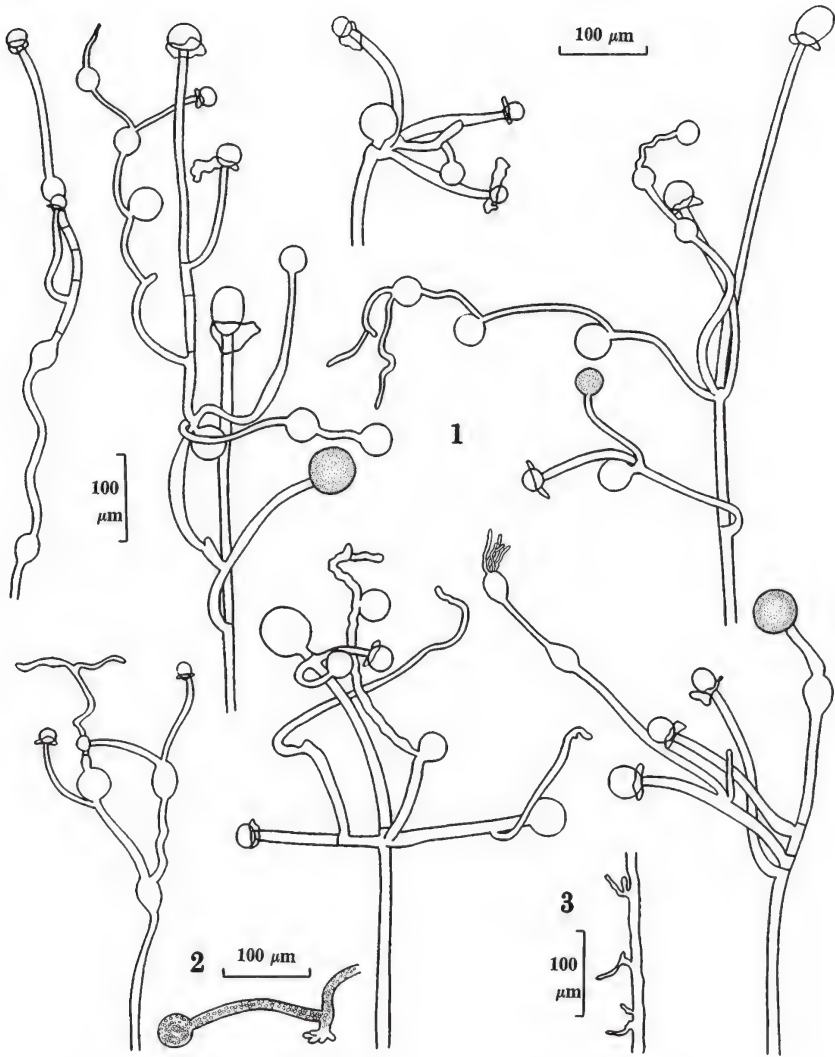


FIGURE 3. *Ambomucor seriatoinflatus* var. *brevior* (AS 3.6784, = Am-2, ex-holotype). 1. Upper portions of sporangiophores, with both fertile and aborted sporangia on the same sporangiophore. Note that the aborted sporangia are mostly in short chains, also that rhizoids are formed at the apical portions of some of the aborted sporangia. 2. Short and finger-like rhizoids formed at the base of the sporangiophore. 3. Simple or branched rhizoids formed on one side of a sporangiophore.

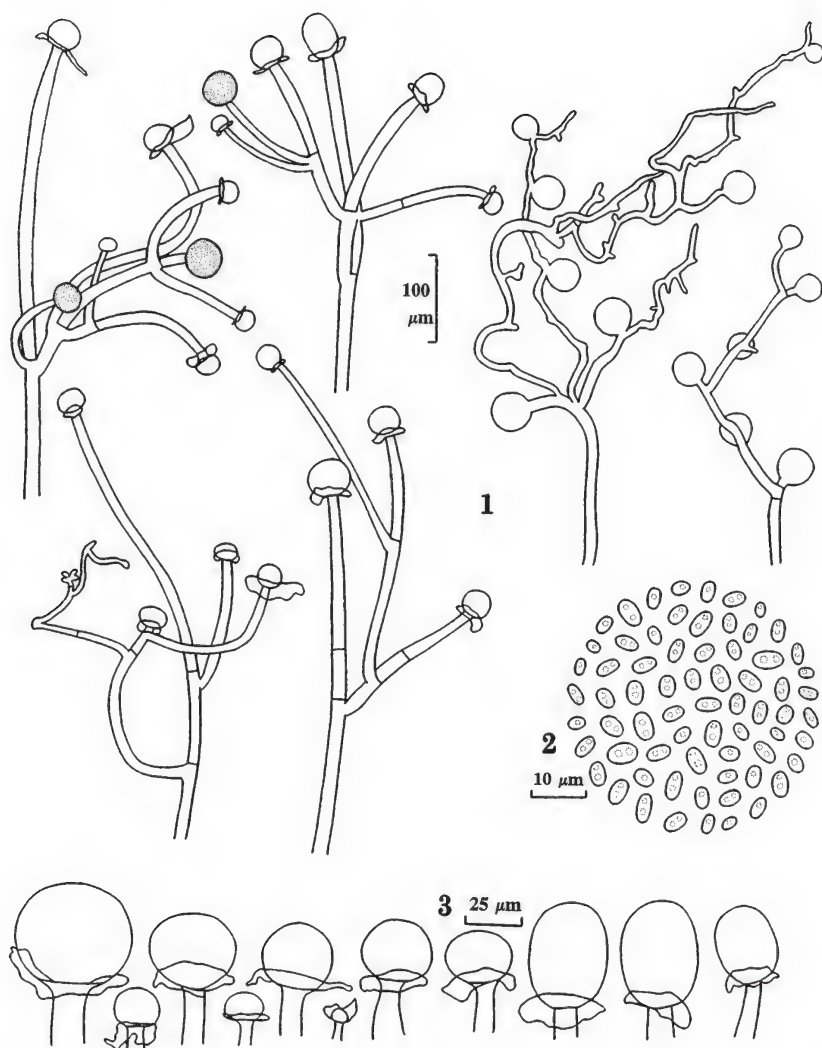


FIGURE 4. *Ambomucor seriatoinflatus* var. *brevior* (AS 3.6784, = Am-2, ex-holotype). 1. Upper portions of sporangiophores, mostly with fertile sporangia, some with aborted sporangia only. Note that sterile outgrowths as well as septa may be formed on some of the sporangiophores. 2. Columellae of various shapes, all with a small collar. 3. Sporangiospores.

COLONIES on SMA and PDA at first subfloccose, then granulate, filling the Petri dish in 6–7 (SMA) or 5–6 (PDA) days at 18°C, about 1–3 mm high, at first

white, then 'Drab Gray' to 'Light Gray' (Ridgway XLVI), reverse cream to light yellowish brown. HYPHAE branching, nonseptate when young, septate in age, (1.5–)7–14(–18.5) μm diam. STOLONS absent. RHIZOIDS scanty, not opposite sporangiophores; arising from various parts of the sporangiophores or the aborted sporangia. SPORANGIOPHORES erect or recumbent, arising directly from substrate or aerial hyphae, of 3 main types: (1) bearing normal fertile sporangia only, (2) bearing aborted sporangia only, (3) bearing both fertile and aborted sporangia on the same sporangiophore; main axes of the sporangiophores rarely simple, usually branched, curved to subcurved, 9–18.5(–22) μm diam.; primary branches 1–4(–10), verticillately branched, (35–)98–437(–500) μm long, 4.5–13(–18) μm diam., curved to subcurved, usually equal or subequal in width throughout, sometimes slightly subequal in width throughout, sometimes slightly narrowed just beneath the terminal sporangia, hyaline to pale greenish brown, with or without granular contents, becoming vacuolated in age. SEPTA in main axes and branches of the sporangiophores usually present at the place of branching, sometimes without definite position. ABORTED SPORANGIA may also borne terminally on the main axes and branches of sporangiophores, or may repeatedly proliferated terminally or laterally, forming intercalary sporangiophores between two aborted sporangia, up to 20 times or more, transferring their contents forward to form a short or long chain of aborted sporangia until formation of a fertile and normal sporangium, globose and (18.5–)32–69 μm diam., or slightly elongate when proliferated, granular when young, vacuolated in age, subhyaline. FERTILE SPORANGIA borne terminally on the main axes or branches of the sporangiophores, globose, (14–)26–64(–88) μm diam.; non-apophysate, breaking or slowly dissolving, thin-walled, dark brown when mature, broken pieces of wall pale grayish brown. COLUMELLAE formed only in fertile sporangia, well developed, very regular in shape, mainly depressed globose to applanate, sometimes oblong-ovoid, rarely globose, hyaline, some with grayish to brownish contents, smooth, regularly with a distinct collar. SPORANGIOSPORES forming only in fertile sporangia, ellipsoid to oblong-ellipsoid, (2.5–)3.5–5 $\times$ (1.5–)2–2.5(–3.5) μm , (1–)2-guttulate, hyaline, grayish in mass, smooth, becoming vacuolated in old cultures. STERILE OUTGROWTHS absent or rarely present and zigzag when present. CHLAMYDOSPORES rare, single, in short chains, or in small masses, subglobose, ovoid or irregular, 5–9 $\times$ 4–7 μm , hyaline to yellow. ZYGOSPORES unknown.

Ambomucor clavatus R.Y. Zheng & X.Y. Liu, sp. nov.

FIG 5

MYCOBANK MB 518402

Differs from *Ambomucor seriatoinflatus* by its ellipsoid aborted sporangia, mostly applanate sporangial columellae, frequent spirally twisted sterile outgrowths, and higher maximum growth temperature.

TYPE: People's Republic of China. Inner Mongolia, Aer Mountain, 47.152486°N 119.976711°E, soil under a larch tree, 16 August 1991, Z.M. Sun (**Holotype** HMAS 240173—1; **ex-holotype** culture CGMCC 3.5877 = Am-3; GenBank KC108740. **Isotypes** HMAS 240173—2–8).

ETYMOLOGY: *clavatus*, referring to the shape of the aborted sporangia.

COLONIES on SMA and PDA at first subfloccose, then granulate, filling the Petri dish in 6–7 (SMA) or 5–6 (PDA) days at 18°C, about 2–4 mm high, at first white then slightly grayish white, reverse dirty white. HYPHAE branching, nonseptate when young, septate in age; 2–4.5 µm diam. STOLONS absent. RHIZOIDS scanty, not opposite sporangiophores or arising from the aborted sporangia, scarcely arising from the lower part of the sporangiophores. SPORANGIOPHORES erect or recumbent, arising directly from substrate or aerial hyphae, of 2 main types: (1) bearing aborted sporangia only, (2) bearing both fertile and aborted sporangia on the same sporangiophore; main axes of the sporangiophores substraight to recurved, rarely simple, usually branched, equal or subequal in width throughout, sometimes slightly narrowed just beneath the terminal sporangia, grayish to light brownish-gray, sometimes with granular contents in the upper part, 5.5–14 µm diam. and reaching a length of 380–762 µm; primary branches 1–3, remaining simple, repeatedly branching 1–2 times, or forming aborted sporangia in a chain of 2–6. SEPTA usually absent, very rarely present at the branches 40–60 µm below the sporangia. ABORTED SPORANGIA also borne terminally on the main axes or branches of the sporangiophores, or repeatedly proliferating terminally or laterally forming intercalary sporangiophores between two aborted sporangia, usually not exceeding 7 in number, transferring their contents forward to form a chain of aborted sporangia until formation of a fertile sporangium, globose and 18.5–41.5 µm diam., or ovoid to ellipsoid and 23–74 × 14–32 µm, granular when young, vacuolate in age, subhyaline to gray in color. FERTILE SPORANGIA borne terminally on the main axes or branches of the sporangiophores, globose, 27.5–78 µm diam., non-apophysate, breaking and usually not dissolving, thin-walled, at first gray, then grayish-brown when mature. COLUMELLAE formed only in fertile sporangia, well developed, mostly applanate to depressed globose and (4–)9–25 × (6–)12.5–34 µm, rarely subglobose and 14–33 µm diam., light grayish-brown, often with a large and distinct collar. SPORANGIOSPORES forming only in fertile sporangia, oblong-ellipsoid, 2.5–4.5(–5.5) × 2–2.5 µm, (1–)2-guttulate, hyaline, grayish in mass, smooth, becoming vacuolate in old cultures. STERILE OUTGROWTHS abundant, mycelium-like, growing out from the tip of the aborted sporangia or from the branches of sporangiophores, spirally twisted. CHLAMYDOSPORES absent. ZYGOSPORES unknown.

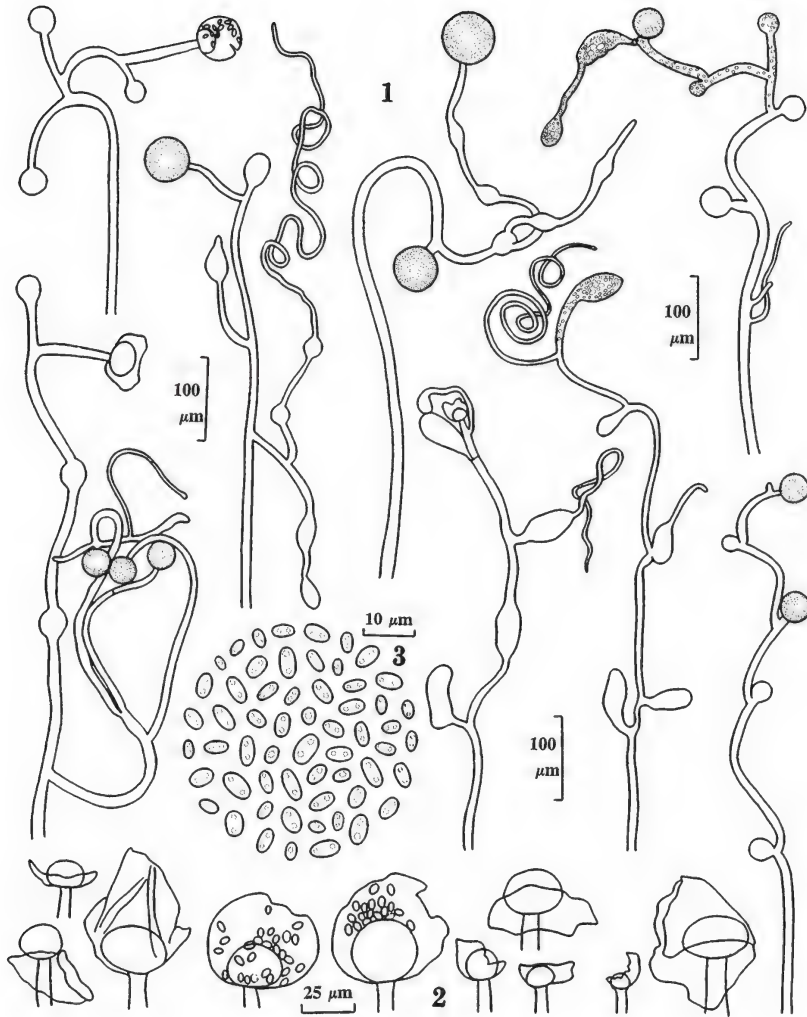


FIGURE 5. *Ambomucor clavatus* (AS 3.5877, = Am-3, ex-holotype). 1. Upper portions of sporangiophores, mostly with both fertile and aborted sporangia on the same sporangiophore, a few with aborted sporangia only. Note that the aborted sporangia are either subglobose or more frequently ovoid to elliptic-ovoid and spirally twisted sterile outgrowths are formed from the upper portion of the aborted sporangia or less frequently from the branches of sporangiophores. 2. Columellae of various shapes, each with a large collar. 3. Sporangiospores.

Key to the taxa of *Ambomucor*

1. Aborted sporangia globoid, ovoid to ellipsoid; columellae of the fertile sporangia mostly applanate, rarely globose to subglobose; sterile outgrowths frequent, often spirally twisted; maximum growth temperature 33°C. *A. clavatus*
1. Aborted sporangia globose to subglobose; columellae of the fertile sporangia mostly globose to subglobose, or ovoid-ellipsoid, smaller ones applanate; sterile outgrowths absent or rare, not spirally twisted when present; maximum growth temperature 30°C. 2
2. Aborted sporangia in chains of 10(–20); sporangiophores never verticillately branched; sterile outgrowths not in zigzags, usually absent; when globose columellae reaching 60 µm diam.; sporangiospores (2.5–)3.5–8 × (1.5–)2–2.5(–3.5) µm *A. seriatoinflatus* var. *seriatoinflatus*
2. Aborted sporangia usually not exceeding chains of 6; sporangiophores sometimes verticillately branched; sterile outgrowths when present often in zigzags; when globose columellae not exceeding 42 µm diam., sporangiospores (2.5–)3.5–5 × 2–3(–4) µm *A. seriatoinflatus* var. *brevior*

Acknowledgements

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Two new species of *Rhytismataceae* on fagaceous trees from Anhui, ChinaLI CHEN¹, D.W. MINTER², SHI-JUAN WANG¹ & YING-REN LIN^{1*}¹ School of Forestry & Landscape Architecture, Anhui Agricultural University,
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ABSTRACT — *Lophodermium circinatum* sp. nov. on *Castanopsis eyrei* and *Terriera nitens* sp. nov. on *Cyclobalanopsis myrsinifolia* and *C. pentacycla* from China are described, illustrated, and discussed. Type specimens are deposited in the Reference Collection of Forest Fungi of Anhui Agricultural University, China (AAUF).

KEY WORDS — conservation, foliicolous fungi, morphology, parasitism, taxonomy

Introduction

During fieldwork in China studying leaf-inhabiting fungi on members of the *Fagaceae*, three specimens of the ascomycete family *Rhytismataceae* were collected. Examination of that material and comparison with species already described led to the conclusion that one specimen represents a new species of *Lophodermium* Chevall. and the other two represent a new species of *Terriera* B. Erikss.

Materials & methods

For microscopic examination, pieces of leaf material with fruitbodies were selected from each collection. The external appearance of the fungal colonies, zone lines, ascomata, and conidiomata were observed with a dissecting microscope at 10–50× magnification. After 10–15 min. in water, fruitbodies were cut into 10–15 µm thick vertical transverse sections using a freezing microtome (YD-202, China). These were mounted in lactic acid or cotton blue (with pretreatment in water) onto microscope slides, and examined. Squash mounts in water, lactic acid or cotton blue were made to observe asci, ascospores and paraphyses. Gelatinous sheaths surrounding ascospores and paraphyses were examined in water or 0.1% (w/v) cotton blue in lactic acid. The colour of internal structures and ascus contents were observed in water. Measurements were made from more than 30 asci, ascospores, paraphyses, conidiogenous cells and

conidia for each specimen using material mounted in 5% KOH or Melzer's reagent. Line and point integrated drawings of external shapes and internal structures of fruitbodies were prepared using a microscope drawing tube (Panasonic XSJ-2, Japan).

Taxonomy

Lophodermium circinatum Li Chen bis & Y.R. Lin, *sp. nov.*

FIGS 1–7

FUNGAL NAME FN570066

Differs from *Lophodermium yangii* by subcuticular ascomata, well-developed lips, much shorter asci and ascospores, and paraphyses with circinate apices.

TYPE: China, Anhui, Qingliangfeng, Zhujiashu, alt. 180 m, on fallen leaves of *Castanopsis eyrei* (Champ. ex Benth.) Hutch. (*Fagaceae*), 4 July 2006, T. Zhang & Y.R. Lin 2129 (Holotype AAUF 68937).

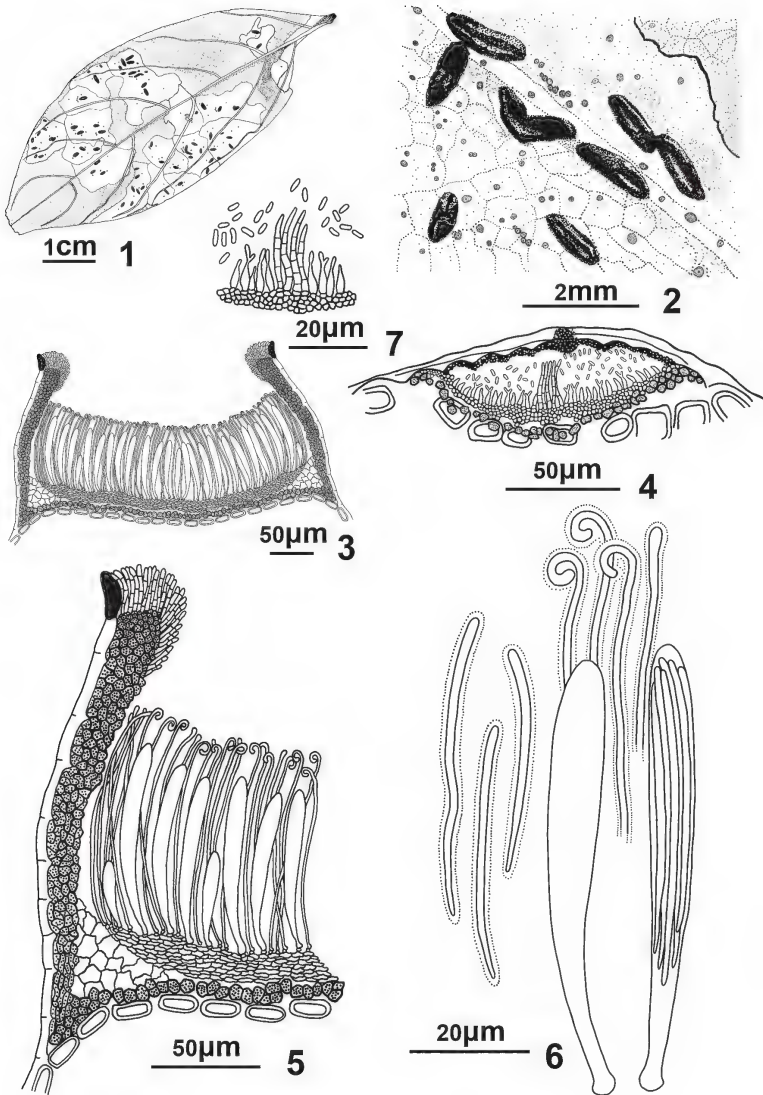
ETYMOLOGY: *circinatum*, referring to the paraphyses, which are circinate at the apex.

COLONIES on both sides of leaves, forming subcircular or irregular, light yellow to grayish-yellow spots, 10–18 mm diam., which tend to coalesce into larger irregular shapes.

ZONE LINES frequent, gray-black and thin, entirely or partly surrounding the paler areas, not always conspicuous.

CONIDIOMATA on both sides of leaves, predominantly on the upper side, crowded, sometimes with several coalescing. In surface view, conidiomata 90–175 × 80–135 µm, almost circular to elliptical, slightly raising the substratum surface, concolorous with the substratum surface or light yellow-brown, dark-brown in the centre and at the perimeter line, often universally brown after spore discharge which occurs through an apical ostiole. In vertical section, conidiomata subcuticular. UPPER WALL 3–6 µm thick, blackish brown, composed of tiny angular cells. BASAL WALL poorly developed, brown to dark brown, consisting of 1–2 layers of angular and globose, thick-walled cells 2.5–4.5 µm diam. SUBCONIDIOGENOUS LAYER 3.5–8 µm thick, consisting of colourless, thin-walled angular cells. TRICHOGYNES 20–28 × 2–3 µm, cylindrical, tapering towards the rounded apex, 4–6-septate. CONIDIOGENOUS CELLS 8–12 × 2–2.5 µm, flask-shape, holoblastic, proliferating sympodially. CONIDIA colourless, aseptate, smooth, cylindrical or elliptical, 3–4.5 × ca 1 µm.

ASCOMATA in similar positions to conidiomata on the substratum, scattered, occasionally with 2 coalescing in the paler areas. In surface view, ascomata 900–1750 × 360–650 µm, elliptical to elongate-elliptical, straight or curved to one side, ends obtuse or slightly acute, black, shiny, with a clearly marked outline, moderately raising the substratum surface but clearly sunken near the split, opening by a single longitudinal split which extends almost to the ascomatal edge. Lips present. In median vertical section, ascomata subcuticular. COVERING STROMA 20–28 µm thick near the opening, slightly thinning towards the edge, connecting to the basal stroma, composed mainly of textura angularis



FIGS 1–7. *Lophodermium circinatum* on *Castanopsis eyrei*. 1. A leaf bearing zone lines and fruitbodies. 2. A zone line and fruitbodies observed under a dissecting microscope. 3. Ascoma in median vertical section. 4. Conidioma in vertical section. 5. Portion of ascoma in median vertical section. 6. Paraphyses, asci, and ascospores. 7. Trichogynes, conidiogenous cells, and conidia.

with dark brown to blackish brown, thick-walled cells 3–5.5 μm diam. LIP CELLS well developed, arranged somewhat radially, 10–24 $\times$ 1.5–2.5 μm , cylindrical, the apical cells sometimes slightly wider, nearly colourless, with black and markedly brittle tissue sticking to the outer side. BASAL STROMA dark brown, composed of 1–2 layers of thick-walled, angular to globose cells 4–6 μm diam. The triangular area, visible in sections between the covering stroma and the basal stroma at each edge of the ascoma, is filled with colourless, gelatinous, thin-walled angular cells 4–9.5 μm diam. SUBHYMENIUM 10–16 μm thick, rather flat, consisting of colourless textura porrecta. PARAPHYSES 90–120 $\times$ 1.2–1.5 μm , filiform, usually curved into uncinat or circinate shapes, sometimes gradually widening to 2–2.5 μm at the apex, and immersed in a ca 1.5 μm thick gelatinous matrix. ASCI ripening sequentially, 70–95 $\times$ 7–9 μm , cylindrical-clavate to cylindrical, somewhat long-stalked, thin-walled, apex rounded, without circumapical thickening, J–, 8-spored. ASCOSPORES arranged in a fascicle, 40–55 $\times$ 1.2–1.6 μm , filiform, colourless, aseptate, slightly tapered towards the rounded base, and immersed in a gelatinous sheath ca 1 μm thick.

ASSOCIATED ORGANISM, HABITAT, AND DISTRIBUTION: *Castanopsis eyrei*, on leaves.

Known only from the type locality, Anhui Province, China.

COMMENTS—*Lophodermium* is the largest genus of the *Rhytismataceae*. IndexFungorum (2013) lists 282 specific epithets for the genus, of which SpeciesFungorum (2013) accepts 135. Although exceptions exist, in the *Rhytismataceae* individual species tend to occur on only conifers, only dicotyledons, or only monocotyledons, while species on dicotyledons tend to occur on either herbs or woody plants but not both. These patterns help limit the taxa for comparison when assessing possible new species.

No *Lophodermium* has been described with type material on *Castanopsis*, but 14 species from IndexFungorum have been recorded on trees of the *Fagaceae* (Cannon & Minter 1986; Farr & Rossman 2013; Johnston 1989a, b, 2001; Lin et al. 2002). *Lophodermium echinophilum* Speg., *L. gamundiae* P.R. Johnst., *L. mahuianum* P.R. Johnst., *L. medium* P.R. Johnst., *L. petiolicola* Fuckel, *L. punctiforme* (Fr.) Fuckel, *L. quercus* S.K. Bose & E. Müll., and *L. yangii* Y.R. Lin & C.L. Hou have type material on other fagaceous genera and are known mainly in association with the *Fagaceae*. *Lophodermium agathidis* Minter & Hettige, *L. eucalypti* (Rodway) P.R. Johnst., *L. foliicola* (Fr.) P.F. Cannon & Minter, *L. maculare* (Fr.) De Not., *L. mangatepopense* P.R. Johnst., and *L. minus* (Tehon) P.R. Johnst. were originally described from leaves of other woody plants but have subsequently also been recorded in association with the *Fagaceae*.

None of the *Lophodermium* species with type material on the *Fagaceae* have paraphyses with circinate apices. *Lophodermium gamundiae*, *L. mahuianum*, and *L. medium* were all described on *Nothofagus* species from New Zealand or southern South America. No anamorph or zone lines have been observed for

L. gamundiae, and lengths of asci (160–190 µm) and ascospores (60–80 µm) are much greater (Johnston & Park 2007) than for our new species. Johnston (1989b) described *L. mahuianum* as never having zone lines or an anamorph, and lengths of asci (130–175 µm) are also much greater. Ascomata of *L. medium* are often triangular in outline and its asci (100–140 µm; Johnston 1989b) are longer than those of *L. circinatum*. Recent evidence suggests that *Nothofagus* should be placed in its own family separate from the *Fagaceae* and the natural distribution of *Nothofagus* in South America and Australasia apparently represents a single population divided when continental drift made Antarctica too cold for plants. Similar distributions might be expected for species of the *Rhytismataceae* evolving with *Nothofagus*. The present fungus is thus clearly different from these three species.

Their protologues described both *L. petiolicola* and *L. punctiforme* as occurring only on petioles and leaf nerves of deciduous species of *Quercus* in Europe. In the north and west of the UK, *L. petiolicola* is common in this habitat, and there are over 100 records of that species throughout Europe and into Georgia (the most western part of Asia) mostly on *Quercus* but also on *Castanea*. [One record on *Sorbus* is probably a misidentification of *L. aucupariae* (Schleich.) Darker.] There are very few records of *L. punctiforme*, all from Europe (Cybertruffle's Robigalia 2013; GBIF 2013). It is possible that these two names represent the same fungus. If so, *L. punctiforme* has priority and would be the correct name.

Lophodermium echinophilum, described from Italy on spines of *Castanea* cupules, may also be a synonym. The paraphyses of these species are not circinate (Tehon 1935). *Lophodermium quercus*, described from India on leaves of the evergreen *Quercus leucotrichophora* A. Camus, has septate ascospores (Cannon & Minter 1986). *Lophodermium yangii*, described from China on leaves of *Cyclobalanopsis glauca* (Thunb.) Oerst., has asci 95–130 µm long. All these species therefore also differ significantly from the present fungus.

Lophodermium agathidis, originally described from leaves of *Agathis australis* (D. Don) Loudon (a conifer) has also been reported from a wide range of other plants including *Castanopsis eyrei* (Lin et al. 2012), apparently an exception to the general patterns described earlier. Developing ascomata of *L. agathidis* have a characteristic pale central band on their surface, the asci are 120–170 µm, and the paraphyses do not have circinate apices. *Lophodermium eucalypti*, which has been recorded on conifers, dicotyledons and monocotyledons, is another apparent exception to that general pattern (Johnston 2001). While it has paraphyses with circinate apices, it does not occur on paler areas of the leaf, nor has it been observed with zone lines or conidiomata. It seems to be an Australasian fungus that has also been recorded, perhaps as an introduction, in North America.

Lophodermium foliicola, a species of Europe and North America, typically associates with members of the *Rosaceae* but has occasionally been recorded from other dicotyledonous families. At least some records on the *Fagaceae* are likely to represent early misidentifications by European mycologists attempting to describe fungi on *Nothofagus* and other plants in the southern hemisphere. Specimens on *Crataegus monogyna* Jacq. from the UK (e.g., IMI 296407) have ascomata that are shorter than 1 mm, asci about 80 µm long, ascospores about 55 µm long, and paraphyses with complex curved and sometimes branched apices. *Lophodermium maculare*, another species of Europe and North America, typically occurs on dead leaves of *Vaccinium* species and has ascomata less than 1 mm long, asci 60–120 µm long, ascospores 55–95 µm long, and paraphyses bent, but not circinate, at the apex. An anamorph has not been observed.

In the protologue, *L. mangatepense*, a predominantly southern hemisphere species, was described as lacking zone lines and conidiomata. Asci were said to be 100–135 µm long and paraphyses to have clavate, not circinate, apices. *Lophodermium minus* has been observed on a wide range of woody plants, mostly in the southern hemisphere, but with some records from China. Paraphyses are uniformly narrow, sometimes branched at the apex, but not circinate. Asci are 100–130 µm long (Cabarro & Minter 2005). Although accepted in *Lophodermium* by SpeciesFungorum, *L. minus* was moved to *Terriera* by Johnston (Ortiz-García et al. 2003) and is discussed again under that name later in the present work.

The other possible generalist *Lophodermium* species not yet recorded in association with the *Fagaceae* is *L. mangiferae* Koord. As in *L. agathidis*, its developing ascomata have a characteristic pale band on their surface. Asci are 95–110 µm long and ascospores 70–75 µm long, while paraphyses tips are widened but not circinate. *Lophodermium circinatum* clearly differs from *L. mangiferae* and all other generalist species considered in the foregoing paragraphs.

***Terriera nitens* Y.R. Lin, sp. nov.**

FIGS 8–13

FUNGAL NAME FN570067

Differs from *Terriera illiciicola* by smaller ascomata, a well-developed excipulum, and swollen paraphyses and from *T. minor* by the almost circular to broadly elliptical ascomata, strongly sunken subhymenium, and the presence of conidiomata and frequent zone lines.

TYPE: China, Anhui, Shitai, Dayan, alt. 1100 m, on leaves of *Cyclobalanopsis myrsinifolia* (Blume) Oerst. (*Fagaceae*), 6 July 2006, T. Zhang & Y.R. Lin 2077 (Holotype AAUF 68885).

ETYMOLOGY: *nitens*, referring to the shiny appearance of ascomata.

COLONIES on both sides of leaves, forming irregular, light yellow bleached spots, 4–10 mm diam.

ZONE LINES frequent, grey-brown to black, thin, surrounding the paler areas.

CONIDIOMATA on both sides of leaves, mostly on the upper side, scattered, occasionally confluent in groups of two or three. In surface view, conidiomata 150–210 µm diam., circular or almost circular, applanate, dark brown in the centre and on the perimeter line of the conidioma, gray-brown or almost concolorous with the substratum surface elsewhere, discharging spores through an apical ostiole. In vertical section, conidiomata subepidermal. UPPER WALL composed of 3–4 layers of nearly colourless, angular cells 3–5.5 µm diam., the cells around apical ostiole blackish brown. BASAL WALL 7–12 µm thick, consisting of 2–3 layers of brown to dark brown thick-walled cells forming a textura angularis. TRICHOGYNES 18–30 × 1.5–2 µm, cylindrical, tapering to the apex, 2–4-septate. CONIDIOGENOUS CELLS and CONIDIA not observed.

ASCOMATA in similar positions to conidiomata on the substratum, crowded in the paler areas. In surface view, ascomata 240–320 × 190–250 µm, suborbicular or broadly elliptical, straight or slightly curved, black, shiny, with a clearly marked outline, strongly raising the surface of the substratum, opening by a single longitudinal split $\frac{3}{4}$ – $\frac{5}{6}$ the length of the ascoma. In median vertical section, ascomata subepidermal. COVERING STROMA 10–16 µm thick near the opening, becoming slightly thinner towards the edge, extending to the basal stroma, composed of textura angularis with dark brown to blackish brown, thick-walled cells 2–3.5 µm diam. Along the edge of the ascomatal opening, there is a 5–8 µm thick, flat extension adjacent to the covering stroma which is comprised of markedly black and brittle tissue with no obvious cellular structure. BASAL STROMA dark brown, comprised of 2–3 layers of 2.5–5 µm diam., thick-walled angular cells. A layer of textura prismatica 8–17 µm thick, composed of nearly colourless or light brown cells 2.5–4.5 µm diam. occurs between the covering and basal stromata. EXCIPULUM 12–16 µm thick near the opening, becoming slightly thinner towards the base, arising from the inner layer of the basal stroma, consisting of colourless textura porrecta. SUBHYMENIUM 5–9 µm thick, strongly concave to form a cup shape, consisting of textura porrecta. PARAPHYSES colourless, thin-walled, smooth, filiform, aseptate, 95–150 × 1–1.2 µm, sometimes swollen at the apex. ASCI ripening sequentially, 85–128 × 4.5–6 µm, narrow cylindrical, somewhat short-stalked, apex round, without circumapical thickening, J–, 8-spored. ASCOSPORES arranged in a fascicle, 68–115 × 0.8–1.2 µm, filiform, colourless, aseptate, round at the apex, slightly tapered towards the acute base, with a thin gelatinous sheath.

ADDITIONAL SPECIMEN EXAMINED — CHINA, HUBEI: Shengnongjia, on leaves of *Cyclobalanopsis pentacycla* (Y.T. Chang) Y.T. Chang ex Y.C. Hsu & H.W. Jen (*Fagaceae*), 10 July 2010, Y.R. Lin & G.J. Jia (AAUF 69308).

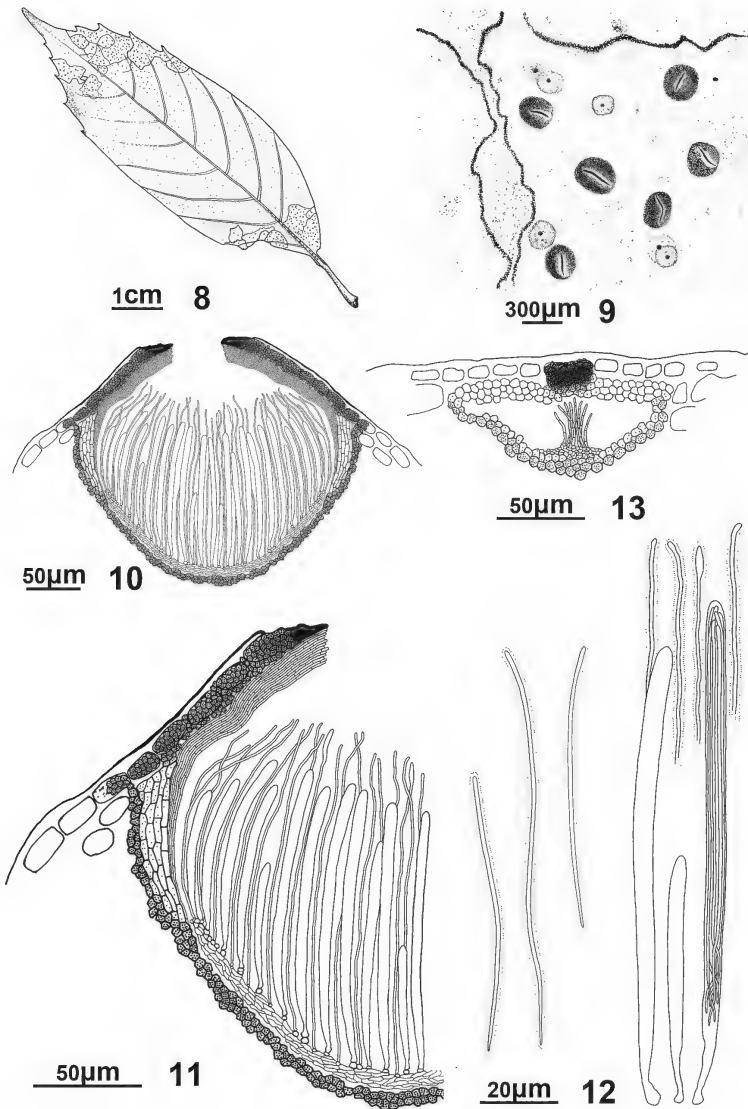
COMMENTS — *Terriera* was established for *T. cladophila* (Lév.) B. Erikss. (Eriksson 1970). IndexFungorum (2013) lists 21 specific and two subspecific

epithets in this genus, of which SpeciesFungorum (2013) accepts 16 species and two varieties in *Terriera*, one epithet in *Lophodermium*, and expresses no opinion about the remaining four epithets, all recent. At least three other species have very recently been described in or transferred to this genus. Most *Terriera* species were originally described in *Lophodermium* or other genera before transfer to *Terriera* by Johnston (Johnston 2001; Ortiz-García et al. 2003). Four *Terriera* species have been recorded associating with trees of the *Fagaceae*: *T. coacervata* Y.R. Lin & Q. Zheng, *T. illiciicola* (S.J. Wang et al.) Q. Zheng & Y.R. Lin, *T. minor* (Tehon) P.R. Johnst., and *T. rotundata* C.L. Hou (Lin et al. 2005, 2012; Song et al. 2012; Zheng et al. 2012).

Terriera coacervata, described on leaves of *Lithocarpus cleistocarpus* (Seemen) Rehder & E.H. Wilson, has ascomata at least 650 (mostly 1000–1800) long, compared with our new species for which the maximum ascomal length is 320 µm. Ascomata of *T. coacervata* tend to coalesce to form complex multiple structures, whereas those of *T. nitens* tend to remain single. There are no records of *T. coacervata* on *Cyclobalanopsis* species.

Terriera illiciicola, described originally on *Illicium verum* Hook. f. (*Schisandraceae*), has also been recorded from the *Fagaceae* on *Lithocarpus cleistocarpus* (Lin et al. 2012). Zheng et al. (2012) reported that *T. illiciicola* does not produce conidiomata, which are abundant in *T. nitens*. Ascomata of *T. illiciicola* are 280–360 × 260–300 µm (Lin et al. 2012) or even larger (300–380 × 280–330 µm; Zheng et al. 2012) while those of *T. nitens* are 240–320 × 190–250 µm so that, despite some overlap, those of *T. illiciicola* are distinctly larger. In comparison with *T. nitens*, the excipulum of *T. illiciicola* is less well developed and paraphyses are not swollen (Zheng et al. 2012). There are no records of *T. illiciicola* on *Cyclobalanopsis* species.

Terriera minor (discussed above under the name *Lophodermium minus*) was originally described from Desecheo Island (Puerto Rico) on *Clusia rosea* Jacq. The holotype is lost, and the species has been neotypified with a collection on *Clusia* sp. from Venezuela (Johnston 1989a). A recent description exists based on *Clusia* specimens from Cuba (Cabarroí & Minter 2005). It differs from *T. nitens* in having no conidiomata in vivo (although conidiomata have been produced in pure culture) and in having more elongated ascomata (0.3–1 mm long), which sometimes coalesce to form more complex structures. When examined in vertical section, the ascoma of *T. minor* has a flat lower wall, a very thin excipulum, and a distinctive flat black area adjacent to both sides of the opening slit, whereas the lower wall in *T. nitens* is strongly curved, the excipulum is thicker, and there is no flat black area adjacent to the opening slit. Paraphyses of *T. minor* are unswollen and sometimes branched, where those of *T. nitens* are often swollen but remain unbranched. There are no records of *T. minor* on *Cyclobalanopsis* species.



FIGS 8–13. *Terriera nitens* on *Cyclobalanopsis myrsinifolia*. 8. A leaf bearing zone lines and fruitbodies. 9. Zone lines and fruitbodies observed under a dissecting microscope. 10. Ascoma in median vertical section. 11. Portion of ascoma in median vertical section. 12. Paraphyses, asci, and ascospores. 13. Conidioma in vertical section.

Terriera rotundata was described from Yunnan, China on dead fallen leaves of *Quercus* sp. The protologue stated that conidiomata were not observed while they are present in *T. nitens*. Ascomata are mostly 600–900 µm long and thus much larger than those of *T. nitens*. The two species are similar in having ascomata that are more or less globular in vertical section, but ascospores of *T. nitens* have thin gelatinous sheaths, which have not been observed for *T. rotundata*. There are no records of *T. rotundata* on *Cyclobalanopsis* species. *Terriera nitens* thus differs from all other species of *Terriera* that have been observed on the *Fagaceae*.

Discussion

Lophodermium circinatum is known only from a single collection, and *Terriera nitens* only from two collections augmented by some field observations. As a result, very little can be said with confidence about their biology. The associated plants, *Castanopsis eyrei*, *Cyclobalanopsis myrsinifolia*, and *C. pentacycla* are evergreen trees with leathery leaves that decay slowly. This type of substratum very often carries species of the *Rhytismataceae*. The main leaf fall is in September and October, and by July of the following year these fungi have produced pale areas on the leaf bearing zone lines, conidiomata with trichogynes, conidiogenous cells and conidia (observed only in *L. circinatum* but probably also produced by *T. nitens*), and ascomata with paraphyses, asci, and ascospores. In the case of *T. nitens*, ascomata with fully formed ascospores are also sometimes observed on dead leaves still attached to the tree. Trichogynes are rarely reported for the *Rhytismataceae* (probably because they are easily overlooked), but their presence here suggests the anamorph has a sexual function, something compatible with the few other reports about anamorph biology in the family.

It is likely that colonization of new substrata is effected in humid condition through wind-dispersed ascospores with a mucous sheath, which may help adhesion. There is not enough information to determine which substrata are colonized by the ascospores. It is possible that they infect leaves already destined to senesce and fall in the following autumn, but that strategy is not typical of rhytismataceous species on evergreen leaves. It is perhaps more likely that the ascospores colonize young leaves produced in the spring of that year, while the leaf cuticle is still soft, and then remain in the leaves as a symptomless endobiont.

There is not enough information to determine any possible positive or negative impacts these fungi might have on their associated trees. It is interesting that there are very few collections. This may simply reflect a past lack of attention to this substratum, but other cases are known in the *Rhytismataceae* where a species may be genuinely rare and only very occasionally seen to fruit.

Lophodermium neesii Duby is a good example of this. It occurs in Europe on dead fallen leaves of *Ilex aquifolium* L., a very abundant tree, but has been collected fewer than ten times in 100 years (Minter 2005). One great value of the present work is that it draws attention to the huge diversity of fungi, an important biodiversity resource too often overlooked.

A good place to start when evaluating the conservation status of leaf-inhabiting fungi is to look at the status of the associated plants. *Castanopsis eyrei*, *Cyclobalanopsis myrsinifolia*, and *C. pentacycla* have not yet been evaluated for the IUCN Red List (2013). All three species occur in a range of arboreta, but such collections rarely if ever protect the microfungi associated with plants in their natural environment. *Castanopsis eyrei* is widely distributed in China (GBIF 2013), and there is no immediate reason to suppose this plant is endangered. GBIF (2013) holds very little information about the distribution of *Cyclobalanopsis myrsinifolia*, and no information at all about *C. pentacycla*, and for these two plants it is not possible to comment on their conservation status in the wild. It is also important to evaluate threats to the ecosystems where these fungi were collected. All three collecting sites for these two species are in or close to nature reserves or other conservation areas, and the status of these sites provides some protection, but in each case the reserve or conservation area is only a small remnant of what was once a more extensive ecosystem. There are also new possible threats. One of the three collection sites is in the Shengnongjia region where the impact of big hydro-electric schemes has aroused international attention (Watts 2011). More information about such developments is needed before proper evaluations can be made of threats to fungi in the region. With the present information, and with only one collection of *L. circinatum* and only two of *T. nitens*, the only possible conservation status evaluation for these fungi is, at present, Data Deficient.

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Three newly recorded species of *Parasymphodiella* and *Chalara* from ChinaXIAO-XIA LI^{1,2}, LI-GUO MA², JI-WEN XIA² & XIU-GUO ZHANG^{2*}¹ Life Science Institute, Zunyi Normal College, Zunyi, Guizhou, 563002, China² Department of Plant Pathology, Shandong Agricultural University, Taian, 271018, China*CORRESPONDENCE TO: zhxg@sdau.edu.cn, sdau613@163.com

ABSTRACT — Three new Chinese records of fungi were discovered from subtropical forests of Guangxi Province, China. *Parasymphodiella laxa*, *P. eucalypti*, and *Chalara unicolor* are described and illustrated from specimens collected on dead branches and compared with closely related species.

KEY WORDS — anamorphic fungi, taxonomy

Introduction

Parasymphodiella was established by Ponnappa (1975) with *P. laxa* as the type species. The genus is characterized by distinct, single conidiophores with terminal and intercalary, integrated, indeterminate, sympodially extending conidiogenous cells that produce catenate, cylindrical, thallic conidia by disarticulations of the fertile hyaline branches. These characters separate *Parasymphodiella* from similar genera such as *Symphodiella* W.B. Kendr. (Kendrick 1958), *Bahusakala* Subram. (Subramanian 1958), *Polyscytalum* Riess (Riess 1853), and *Neoscytalidium* Crous & Slippers (Crous et al. 2006). *Parasymphodiella* currently includes 10 accepted species.

Rabenhorst (1844) introduced *Chalara* for the single species *Torula fusidioides* Corda. The genus has been defined as having distinct, solitary or loosely aggregated conidiophores with monophialidic, integrated, terminal, determinate apical conidiogenous cells that produce catenate, endogenous, cylindrical phialospores. *Chalara* is similar to *Chaetochalara* B. Sutton & Piroz. (Sutton & Pirozynski 1965), *Thielaviopsis* Went (Went 1893), and *Fusichalara* S. Hughes & Nag Raj (Hughes & Nag Raj 1973) in having phialidic conidiogenous cells with a deep cylindrical collarete. Of the more than 130 species described in *Chalara*, *C. ampullula* (Sacc.) Sacc., *C. aotearoa* Nag Raj & S. Hughes,

C. cylindrosperma (Corda) S. Hughes, *C. sinensis* W.P. Wu, and *C. ungeri* Sacc. have previously been reported from China (Zhuang 2001, 2005).

During a continuing survey of subtropical microfungi from the forests of Guangxi Province, China, three new Chinese records of *Parasymphodiella* and *Chalara* were collected on decaying branches. They are described and illustrated below.



FIG. 1. *Parasymphodiella laxa*.

A. Colonies on natural substratum; B. Conidiophores and conidiogenous cells; C, D. Conidia.

Parasymphodiella laxa (Subram. & Vittal) Ponnappa, Trans. Br. Mycol. Soc. 64: 344, 1975.

FIG. 1

COLONIES on natural substrate effuse, brown to blackish brown, hairy. Mycelium superficial and immersed, consisting of branched, septate, hyaline to pale brown hyphae. CONIDIOPHORES distinct, solitary, unbranched, erect, cylindrical, $\leq 780 \mu\text{m}$ long, 1–9-septate; sterile part dark brown, with

a thickened wall, 6–9 μm wide, swollen base $\leq 18 \mu\text{m}$ wide; fertile part grey-brown, later becoming paler toward the apex. CONIDIOGENOUS CELLS terminal and intercalary, integrated, indeterminate, with sympodial extensions and one conidiogenous locus per cell, smooth, pale grey-brown, becoming hyaline toward the apex, $42\text{--}78 \times 6.3\text{--}9.4 \mu\text{m}$ between conidiogenous loci. CONIDIA thallic-arthric, forming in loose chains, hyaline, dry, smooth, thin-walled, cylindrical, $23\text{--}40 \times 7\text{--}10 \mu\text{m}$, (0–)3(–4)-septate, apex and base of intercalary conidia truncate, apical conidia with obtuse or rounded apex.

SPECIMEN EXAMINED: CHINA, GUANGXI PROVINCE: Dayaoshan Nature Reserve, on decaying twigs of an unidentified broadleaf tree, 7 Nov. 2012, X.X. Li (HSAUP H9021, HMAS 243426).

COMMENTS – This is the first report of this species in China. The conidia of the specimen examined are somewhat shorter and wider than the material originally described by Ponnappa ($18\text{--}50 \times 6\text{--}8 \mu\text{m}$; Ponnappa 1975), but we believe they are the same species. *Parasymphodiella laxa* is similar to *P. elongata* Crous et al. in conidial morphology, but *P. elongata* differs by its much longer conidiophores ($\leq 1300 \mu\text{m}$; Crous et al. 1995).

Parasymphodiella eucalypti Cheew. & Crous, Persoonia 23: 70, 2009. FIG. 2

COLONIES on natural substrate effuse, brown to blackish brown, hairy. Mycelium superficial and immersed, consisting of branched, septate, hyaline to pale brown hyphae. CONIDIOPHORES distinct, solitary, unbranched, cylindrical, $\leq 670 \mu\text{m}$, ≤ 13 -septate; sterile part with a thickened wall, medium to dark grey-brown, 6–8 μm wide; fertile part thin-walled, pale grey-brown at basal region, paler toward the apex. CONIDIOGENOUS CELLS terminal and intercalary, integrated, indeterminate, extending sympodially, with one conidiogenous locus per cell, smooth, pale grey-brown, becoming hyaline toward the apex. CONIDIA thallic-arthric, hyaline to very pale brown, dry, smooth, thin-walled, cylindrical, $28\text{--}54 \times 6\text{--}9 \mu\text{m}$, (0–)1(–2)-septate, somewhat swollen in the apical cells, apex and base of intercalary conidia truncate, with a punctiform septal plug at each end, apical conidia with obtuse or round apex, occurring in unbranched chains.

SPECIMEN EXAMINED: CHINA, GUANGXI PROVINCE: Dayaoshan Nature Reserve, on decaying twigs of an unidentified broadleaf tree, 10 Nov. 2012, X.X. Li (HSAUP H9038, HMAS 243427).

COMMENTS – *Parasymphodiella eucalypti* is reported for the first time from China. The conidia of the Chinese specimen are narrower than those of the type material (width 8–11 μm ; Cheewangkoon et al. 2009), but other features of our material closely match those of the original description. *Parasymphodiella eucalypti* resembles *P. elongata* in conidial shape, but *P. elongata* has slightly shorter and wider conidia ($20\text{--}40 \times 6\text{--}12 \mu\text{m}$; Crous et al. 1995).

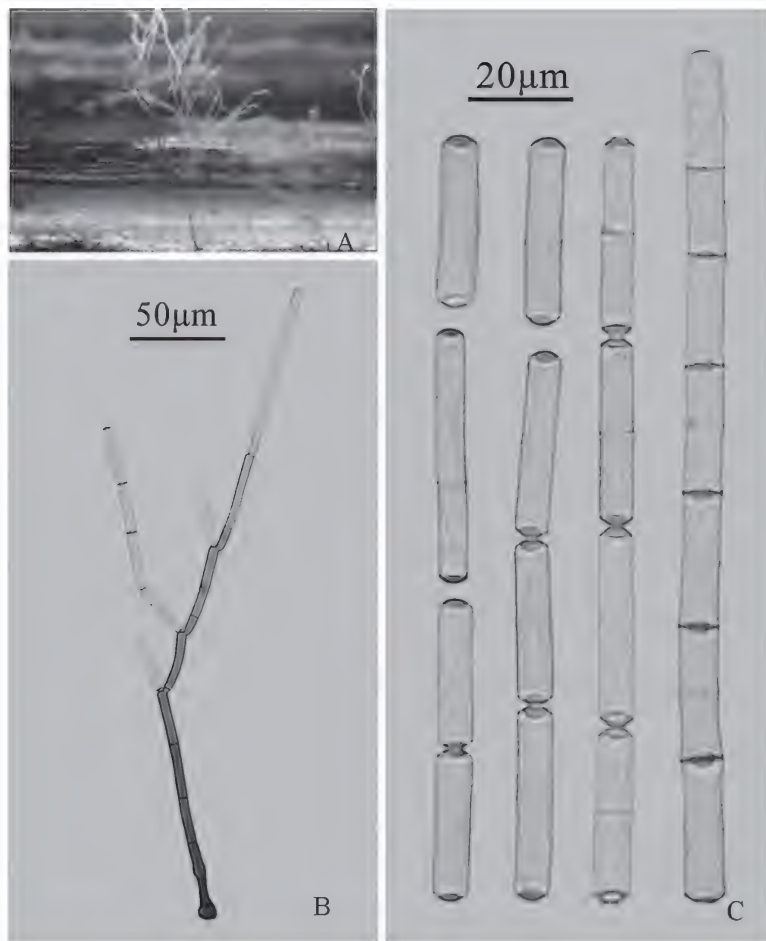


FIG. 2. *Parasymphodiella eucalypti*.

A. Colonies on natural substratum; B. Conidiophores and conidiogenous cells; C. Conidia.

Chalara unicolor S. Hughes & Nag Raj, New Zealand J. Bot. 12: 121, 1974. FIG. 3

COLONIES on natural substrate superficial, effuse, brown, hairy, with a thin white bloom of conidial chains. Mycelium mostly immersed in the substrate. CONIDIOPHORES solitary or loosely aggregated, erect, straight, subcylindrical, uniformly brown, smooth, walls thickened somewhat below and thinner above, 85–130 μm long, composed of a short basal stalk cell, 8.6–9.5 μm wide with an apical phialide. CONIDIogenous CELLS phialides with a slightly inflated venter about 11–14 μm wide merging into a long, cylindrical collarette 8–9 μm wide.

CONIDIA cylindrical, barely rounded at the apex and flattened at the marginally frilled base, hyaline, 3-septate, smooth, $24\text{--}34 \times 7\text{--}8 \mu\text{m}$, sometimes observed in readily seceding chains.

SPECIMEN EXAMINED: CHINA, GUANGXI PROVINCE: Guposhan National Forest Park, on decaying twigs of an unidentified broadleaf tree, 9 Nov. 2012, X.X. Li (HSAUP H9026, HMAS 243428).

COMMENTS – This species has not been previously reported in China. The Chinese collection has shorter conidia than those of the type material ((20–) 34–40(–45) μm ; Nag Raj & Hughes 1974), but otherwise fits well with the original description. *Chalara unicolor* is similar to *C. magnispora* Matsush. in conidial shape, but *C. magnispora* conidia are larger and sometimes 4-septate (25–45(–56) $\times$ 7.5–10.5 μm ; Matsushima 1993).

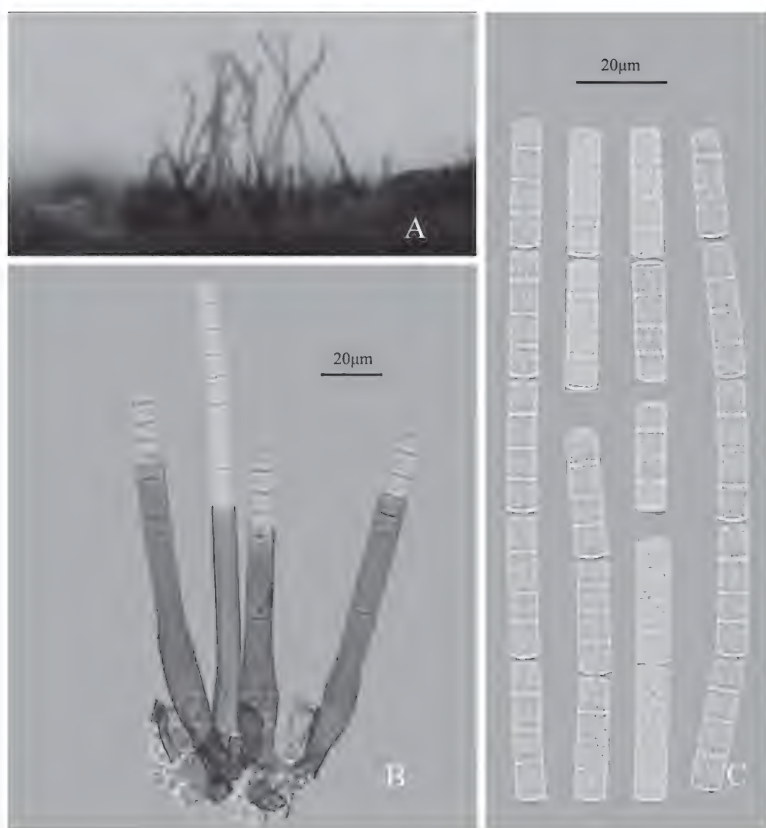


FIG. 3. *Chalara unicolor*.

A. Colonies on natural substratum; B. Conidiophores and conidiogenous cells; C. Conidia.

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***Tuber bomiense*, a new truffle species from Tibet, China**

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ABSTRACT — *Tuber bomiense* sp. nov. is described based on collections from the Bomi region of Tibet, China. It differs from other *Tuber* species by its rust brown ascomata with a verrucose and glabrous surface and ascospores with a regular reticulum. Molecular analysis supports the erection of this new species.

KEY WORDS — *Pezizales*, taxonomy, phylogeny

Introduction

Tibet is a unique region characterized by its high elevation and a wide range of environments. In particular, the Linzhi region, which is located in the Yaluzangbu River valley in southeastern Tibet, has a warm moist climate and a vegetation known as “Tibetan Jiangnan” (‘jiangnan’ refers to warmth and green scenery). Virgin biodiverse forests of pine and oaks cover the valley floors and slopes.

Almost no research has been conducted on the hypogeous fungi of Tibet although *Tuber liui* A.S. Xu, *T. xizangense* A.S. Xu, and *T. oligospermum* (Tul. & C. Tul.) Trappe. have been recorded from the Linzhi region (Xu 1999; Chen 2007). Since 2010 the authors have systematically searched for truffles in the Linzhi region and have made a few collections of both whitish and black species. Here we describe and name one of these new species *Tuber bomiense*.

Materials & methods

The macroscopic and microscopic characters of the new species were described based on fresh specimens following the methods of Yang & Zhang (2003). Sections

were made with a razor blade, mounted in water and examined under a Nikon E400 microscope. For scanning electron microscopy (SEM), spores were scraped from the dried gleba onto doubled-sided tape, mounted directly onto an SEM stub, coated with gold-palladium, and examined and photographed with a JEOL, JMS-5600LV SEM. The holotype (SKM101) is deposited in the Herbarium of Yunnan Academy of Agricultural Sciences, Kunming, China (YAAAS).

DNA was extracted from ascomata using CTAB according to Doyle (1987) modified by adding 200 µL 5M potassium acetate after the 4×CTAB treatment. The primers ITS1F (Gardes & Bruns 1993) and ITS4 (White et al. 1990) were used to amplify the ITS-rDNA region of the DNA extract, and the PCR reaction solution and cycling parameters followed Chen & Liu (2007). Amplification products were electrophoresed on a 1% agarose gel, and purified with Sangon's purification kit. Sequencing was performed with a BigDye Terminator v3.1 Cycle Sequencing Kit on an ABI 3730XL automatic sequencer.

TABLE 1. Origin of the fungal sequences included in the molecular analyses.

TAXON	VOUCHER/CODE	ORIGIN	GENBANK*
<i>Choiromyces alveolatus</i>	MES97	California, USA	HM485332
<i>Tuber bomiense</i>	SKM101	Bomi, Tibet, China	KC517480
	SKM106	Bomi, Tibet, China	KC517481
<i>T. borchii</i>	K(M)23814	unknown	EU784423
<i>T. foetidum</i>	B-2489	Szigetujfalu, Hungary	AJ557544
<i>T. indicum</i>	Clone C4	Unknown	AF106883
	Clone D3	Unknown	AF106884
	Clone C98-9	Unknown	AF106881
<i>T. macrosporium</i>	Clone Macro1	Central Umbria, Italy	AF106885
<i>T. maculatum</i>	MTM2012	Nida's Valley, Poland	JX559773
<i>T. magnatum</i>	Clone Ma2	Central Umbria, Italy	AF106888
<i>T. melanosporium</i>	Clone A51	Northern Piedmont, Italy	AF106876
	Clone A71	Spain	AF106877
	Clone A62	France	AF106879
<i>T. mesentericum</i>	Clone Mese4	Central Umbria, Italy	AF106887
<i>T. nitidum</i>	AH39101	Morocco	JX402092
	AH11906	Spain	JX402090
<i>T. rapaeodorum</i>	K(M)7705	Unknown	EU784430
<i>T. rufum</i>	GK4422	Greece	JX402094
	AH39102	Morocco	JX402093
<i>T. scruposum</i>	CMI-UNIBO 2207	Dilijan, Armenia	DQ011847
	CMI-UNIBO 2201	Dilijan, Armenia	DQ011845
<i>T. whetstonense</i>	Strain LO8B	California, USA	JF419244
	JT25783	Oregon, USA	HM485392
	SOC 756	Unknown	AY830855

*Sequences produced in this study in bold.

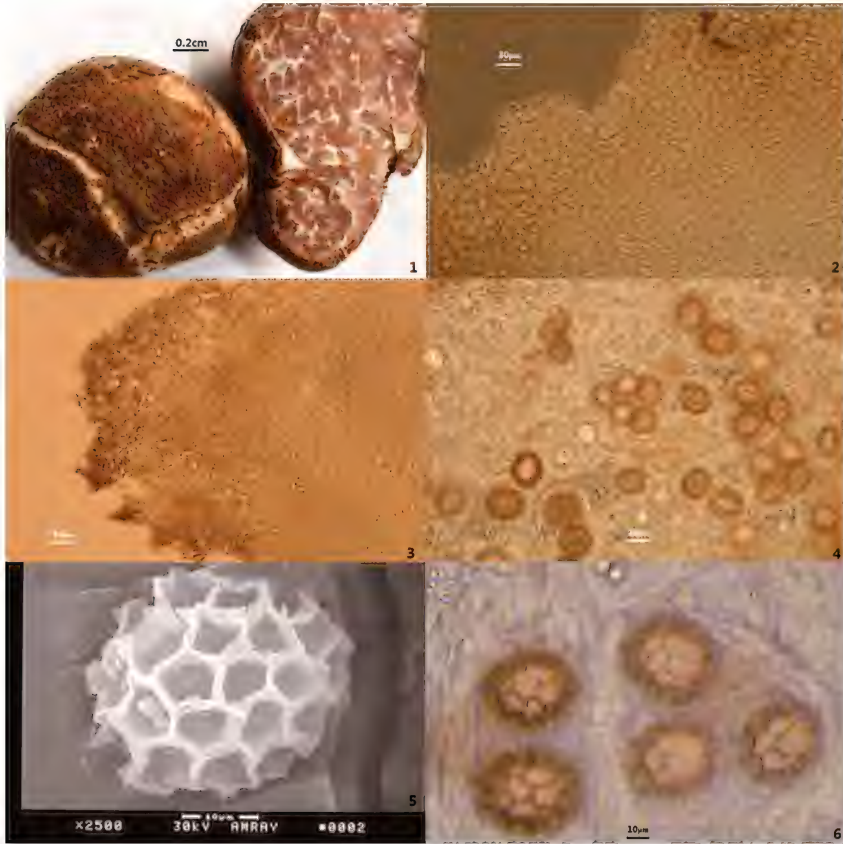


PLATE 1. *Tuber bomiense* (YAAS SKM101). 1. Ascomata; 2–3. Peridial structure of one ascoma; 4. Asci (light microscope); 5. Ascospore (SEM); 6. Ascospores (light microscope).

The two *T. bomiense* ITS-rDNA sequences extracted in this study were compared with 24 *Tuber* ITS-rDNA sequences downloaded from NCBI (TABLE 1); *Choiromyces alveolatus* was selected as the outgroup. Software and sequence alignment and phylogenetic protocols followed Chen & Liu (2007).

Taxonomy

Tuber bomiense K.M. Su & W.P. Xiong, sp. nov.

PLATE 1

MYCOBANK MB 803258

Differs from other *Tuber* species by its rust brown ascomata with verrucose and glabrous surface and subglobose to broadly ellipsoid ascospores with regular reticulum.

TYPE: China: Linzhi region, Bomi County, Yigong Town, 30°14'N 94°54'E, alt. 2390 m, in forest of *Pinus densata* Mast., 16.10.2011, Kaimei Su (**Holotype**, YAAS SKM101; GenBank KC517480).

ETYMOLOGY: from the Latin *bomiense* referring to the location of the type collection.

ASCOMATA subglobose or irregular, firm, rust-brown to brown, up to 2.0 cm diam, surface verrucose, glabrous, cracked into small polygonal segments. ODOR slightly aromatic when mature. PERIDIUM 230–520 μm thick, two layers, the outer layer 112.5–217.2 μm thick, pseudoparenchymatous, composed of large polygonal to subglobose cells 3–10 $\times$ 5–12 μm diam, brownish to brown, thin or thick walled 1–3 μm thick, the inner layer 94.8–191.9 μm thick, composed of hyaline to pale yellow interwoven hyphae. GLEBA solid, whitish when young, becoming rust brown at maturity, marbled with distinct, white, meandering veins merging at many points within the peridium. ASCI 63–78 $\times$ 45–63 μm , subglobose, rhombic, ellipsoid or irregular, sessile, thin walled 1–2 μm thick, 1–4(–5) spored, randomly dispersed in glebal tissue. ASCOSPORES subglobose to broad ellipsoid, in 1-spored asci 42.0 $\times$ 35.6 μm , 2-spored asci 35.2 $\times$ 30.4 μm , 3-spored asci 34.3 $\times$ 31.0 μm , 4-spored asci 28.7 $\times$ 25.1 μm , 5-spored asci 26.8 $\times$ 23.2 μm ; $Q = (1.06\text{--})1.07\text{--}1.29\text{--}(1.32)$, $Q_m = 1.18 \pm 0.08$ (72/8/4); spore walls 25 μm thick, brown at maturity, ornamented with a regular alveolate-reticulum, up to 6 μm deep, formed by mostly hexagonal meshes 8–15 $\times$ (5–)7–13 μm , 4–5 along the spore length and (2–)3–4 across the spore width.

ECOLOGY & DISTRIBUTION: Hypogeous in calcareous soils with pH 7.4 under *Pinus densata* at an elevation of c. 2400 m, fruiting in late October. Known only from Cegang Village, Yigong, Bomi County, Linzhi region, Tibet, China.

ADDITIONAL SPECIMEN EXAMINED: CHINA: Linzhi region, Bomi County, Yigong Town, 30°15'N 94°54'E, alt. 2400 m, in *Pinus densata* forest, 16.10.2011, Kaimei Su (YAAS SKM106; GenBank KC517481).

Phylogenetic analysis

A total of 25 ITS *Tuber* sequences were used in the phylogenetic analysis (TABLE 1) with an ITS *Choiromyces alveolatus* sequence as the outgroup. The MP tree (PLATE 2) includes 776 steps (CI = 0.772, RI = 0.912).

Phylogenetic analysis of the ITS sequences revealed two well-supported clades. *Tuber borchii*, *T. maculatum*, and *T. foetidum* are included in clade 1 with 99% bootstrap support. Clade 2 is composed of *T. whetstonense*, *T. scruposum*, and *T. bomiense* with 100% bootstrap support. In Clade 2, *T. bomiense* and *T. scruposum* formed a subclade with 79% bootstrap support. The result of phylogenetic analysis shows that *T. bomiense* differs from all other truffle species but is related to *T. scruposum* (PLATE 2).

Discussion

Tuber bomiense differs morphologically from all other truffle species by its rust brown ascomata with a hairless verrucose surface cracked into

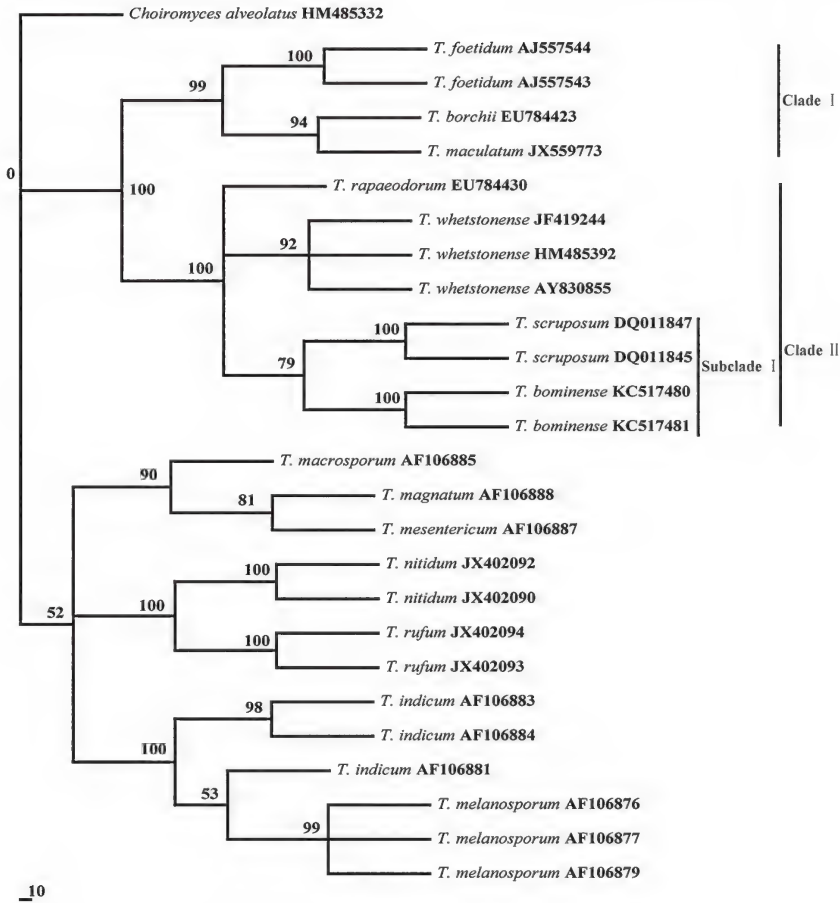


PLATE 2. Equally weighted parsimony tree of *Tuber* species based on ITS sequence.

small polygonal segments, and its ascospores are more subglobose than ellipsoid (PLATE 1, FIGS. 1, 4). It is morphologically close to *T. quercicola*, *T. rapaeodorum*, *T. scruposum*, and *T. whetstonense* (TABLE 2). *Tuber quercicola* has a similarly cracked peridium but its spiny ascospores distinguish it (Frank et al. 2006). *Tuber rapaeodorum* differs in having pubescent ascomata and ellipsoid ascospores with denser meshes. In *T. scruposum* the ascoma surface is ochraceous tawny to dull ochraceous orange and its ascospores are more ellipsoid than subglobose with narrow meshes (Ceruti et al. 2003). Finally, *T. whetstonense* differs from *T. bomiense* by a pubescent peridium and ellipsoid ascospores with much denser meshes (Ceruti et al. 2003; Frank et al. 2006).

TABLE 2. Morphological differences between *Tuber bominense* and similar *Tuber* species

SPECIES:	<i>bominense</i>	<i>quercicola</i>	<i>rapaeodorum</i>	<i>scruposum</i>	<i>whetstonense</i>
PERIDIUM SURFACE	Verrucose, cracked	Minutely verrucose to scaly, cracked	Smooth to finely pubescent	Slightly warty, finely pubescent	Minutely scurfy, pubescent
GLEBA COLOR	Rust brown	Light tan to dk reddish brown	Dark brown	Greyish vinaceous	Dark greyish
SPORE SHAPE	Subglobose / ellipsoid	Ellipsoid	Ellipsoid	Ellipsoid	Subglobose / ellipsoid
SPORE COVERING	Reticulate; meshes broad	Spiny; spines curved	Reticulate; meshes dense	Reticulate; meshes dense	Reticulate; meshes very dense

The phylogenetic analysis also shows that *T. bomiense* is distinct from these similar species (PLATE 2). The discovery of *T. bomiense* in Tibet provides further evidence of the close phylogeographic relationship between Chinese truffles and European and American species.

Acknowledgements

We are grateful to Dr Ian R. Hall and Associate Professor Li Fan for reviewing the paper and providing valuable comments. This study received financial support from the Chinese modern agricultural technology funding system (CARS-24).

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***Lepiota brunneoincarnata* and *L. subincarnata*:
distribution and phylogeny**A. RAZAQ¹*, E.C. VELLINGA², S. ILYAS¹ & A.N. KHALID¹¹Department of Botany, University of the Punjab, Lahore. 54590, Pakistan²Department of Plant and Microbial Biology, University of California Berkeley California USA*CORRESPONDENCE TO: ectomycorrhiza@gmail.com

ABSTRACT — An updated phylogeny of the clade of toxic *Lepiota* species is presented, and new insights in the distribution of *L. brunneoincarnata* and *L. subincarnata* are given. *Lepiota brunneoincarnata* is widespread in Europe and temperate Asia, and *L. subincarnata* is now known from Asia, Europe, and North America. Morphological and anatomical descriptions are provided for these two species based on material from the western Himalayan forests in Pakistan, where they are reported for the first time.

KEYWORDS — amatoxins, lepiotaceous fungi, mushroom diversity, rDNA

Introduction

Among lepiotaceous fungi the genus *Lepiota* (Pers.) Gray (*Agaricales*, *Basidiomycota*) has a worldwide distribution and is highly diversified (Bon 1993; Ahmad et al. 1997; Vellinga 2003; Kirk et al. 2008; Razaq et al. 2012; Nawaz et al. 2013). The genus is characterized by having a scaly (rarely smooth) pileus, free lamellae, partial veil in the form of annulus, a universal veil, smooth white dextrinoid spores (in most species), and clamp connections (present in all but one or two species) (Vellinga 2001, Kumar & Manimohan 2009). The nature of the pileus covering elements and the spore shape are very important characters for infrageneric classification (Candusso & Lanzoni 1990; Bon 1993; Vellinga 2001, 2003). The pileus covering of *Lepiota* is a hymeniderm, a trichoderm, an epithelium made up of long or globose elements, or cutis-like (Vellinga 2001, 2003). Bon (1993) and Vellinga (2001) recognized two subsections in sect. *Ovisporae* (J.E. Lange) Kühner, a section morphologically characterized by ellipsoid spores and a trichodermal pileus covering based on structure and size of the pileus elements: subsect. *Helveolinae* Bon & Boiffard with a trichoderm made up of only longer pileus elements and subsect. *Felininae* Bon with long and basal short elements. Vellinga (2003) discovered that sect.

Ovisporae is not monophyletic: species of subsect. *Felininae* clustered with sect. *Lepiota*, while species of subsect. *Helveolinae* clustered with species with spurred spores in sect. *Stenosporae* (J.E. Lange) Kühner. The clade of subsect. *Helveolinae* is represented by the European species *L. brunneoincarnata*, *L. subincarnata*, and *L. farinolens* Bon & G. Rioussset, plus the tropical species *L. elaiophylla* Vellinga & Huijser. Both *L. brunneoincarnata* and *L. subincarnata* are infamous for amanitin poisoning (Gérault & Girre 1975; Bresinsky & Besl 1985). Such poisonings from *Lepiota* species result in liver and kidney failure and, if not treated in time, death in humans (Khelil et al. 2010; Delacour et al. 2009; Donnelly et al. 2000; Haines et al. 1985).

Collected during fieldwork in the moist temperate forests of western Himalaya dominated by coniferous vegetation, *L. brunneoincarnata* and *L. subincarnata* have not previously been documented for Pakistan and are here described morphologically and molecularly. *Lepiota subincarnata* is known from several parts of North America, Europe, and eastern Himalaya, and *L. brunneoincarnata* occurs throughout Europe and in eastern China. ITS-rDNA sequences of these two species are now available from different regions of the world. The objective of this paper is to provide a precise description of the Pakistani material, to evaluate the phylogenetic relationship among all isolates of these species from Asia, Europe, and North America, and to place the species in a phylogenetic context.

Materials & methods

The basidiomata were carefully dug up using a knife and photographed in the field. Material was characterized morpho-anatomically and molecularly. For microscopic observation, sections were stained with Congo Red and Melzer's reagent. Dimensions were determined for 25 basidiospores, 20 basidia, 20 cheilocystidia, and 20 elements of pileus covering from each basidioma. The following abbreviations are used: avl for average length, avw for average width, Q for the basidiospore length-width ratio, and avQ for average of all Q. Drawings were made using a camera lucida attached to a compound microscope. Dried specimens were deposited in the LAH Herbarium, Department of Botany, University of the Punjab, Lahore.

The protocol of Extract-N-Amp (XNAP-2) (Sigma, St. Louis, MO, USA) was followed. Dried material of basidioma (approx. 1 mg) was taken in small PCR tubes to which 10 µl of extraction solution was added. These tubes were incubated at 65°C for 10 min then at 94°C for 10 min. After the addition of 10 µl dilution solution (XNAP-2), the tubes remained at room temperature for one hour. ITS regions of rDNA were amplified using the universal primer pair ITS1F and ITS4 (White et al. 1990, Gardes and Bruns 1993). PCR was performed in 25 µL reaction volume following Gardes and Bruns (1993). PCR product of the ITS1+5.8S+ITS2 region was directly sequenced in both directions using the same amplification primers (Macrogen, Korea).

All available ITS sequences of species in subsect. *Helveolinae* plus selected species in subsect. *Felininae* and sect. *Lepiota* were downloaded from GenBank. *Coprinus comatus*

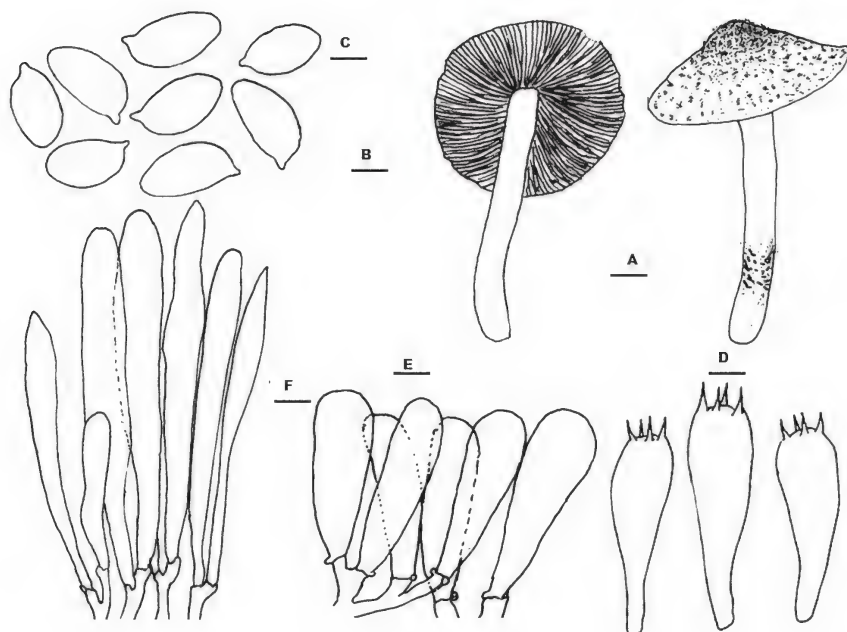


FIG. 1: *Lepiota brunneoincarnata*. A, B. Basidioma. C. Basidiospores. D. Basidia E. Cheilocystidia. F. Pileus covering elements. Scale bars: A, B = 1 cm; C = 3.45 μ m; D = 6.25 μ m; E = 13 μ m; F = 21.25 μ m.

was used as outgroup. The sequences were aligned using MAFFT version 6 (Katoh et al. 2002, Katoh & Toh 2008) with default settings. The total 34-sequence dataset was analyzed by a maximum likelihood (ML) method with RAxML 7.2.3 (Stamatakis et al. 2008). All free-model parameters were estimated by RAxML with a general time reversible (GTR) substitution matrix and a proportion of invariable sites estimated. One hundred ML bootstraps were performed.

The newly produced nucleotide sequences were submitted to the European Molecular Biology Laboratory (EMBL) database and are available in GenBank. Numbers are listed with the collections and in FIG. 3.

Results

Lepiota brunneoincarnata Chodat & C. Martin, Bull. Trav. Soc. Bot.

Genève 5: 222. 1889.

FIG. 1

PILEUS 2.6 cm diam., campanulate to plano-convex, with obtuse to slightly umbonate central disc and deflexed margins; central disc with greyish-brown to dark brown scales on white to cream or pinkish buff background, around center concentric crowded and prominent squamules slightly paler or lighter

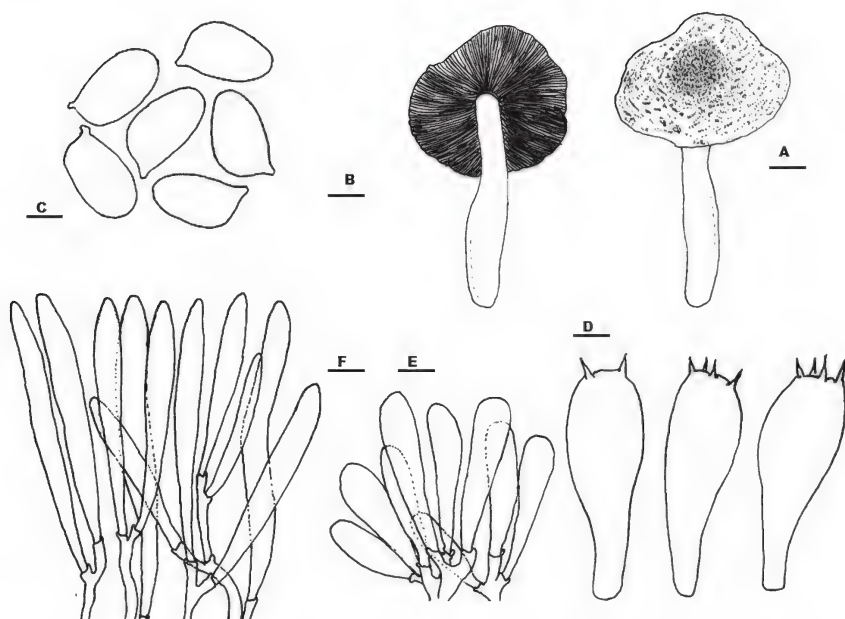


FIG. 2: *Lepiota subincarnata*. A, B. Basidioma. C. Basidiospores. D. Basidia. E. Cheilocystidia. F. Pileus covering elements. Scale bars: A, B = 1 cm; C = 3.45 μm ; D = 6.25 μm ; E = 13 μm ; F = 21.25 μm .

toward margin, made up of small pyramids; margin smooth, at maturity fragile and broken. LAMELLAE free, moderately crowded, white to cream, with 2–3 tiers of lamellulae alternating with lamellae; edges wavy to denticulate. STIPE 4.2 $\times$ 0.3 cm, centrally attached, cylindrical, dark-brown to dull brown, light brown to pinkish brown in apical half, smooth in upper part, scaly in lower part; scales in bands forming incomplete girdles, non-persistent annulus; white basal mycelial strands. TASTE not recorded.

BASIDIOSPORES 5–8.5 $\times$ 3.5–5.5 μm , $\text{avl} \times \text{avw} = 6.5 \times 4.5 \mu\text{m}$, $Q = 1.4\text{--}1.5$, $\text{av}Q = 1.45$, ellipsoid to ovoid, slightly amygdaliform, smooth, moderately thick-walled, colourless or pale yellow in 5% KOH, reddish brown in Melzer's reagent and strongly dextrinoid; wall colouring in Cresyl Blue not observed. BASIDIA 21–31.5 $\times$ 8–9.5 μm , 4-spored, subclavate to clavate, hyaline to pale yellow in 5% KOH, thin-walled, with oil-like contents. PLEUROCYSTIDIA absent. CHEILOCYSTIDIA 18.5–31 $\times$ 8–10.5 μm , usually clustered, hyaline, thin-walled, narrowly clavate to clavate. PILEUS COVERING a trichoderm with erect or ascending, light brown to hyaline, clamped terminal elements, 90–253 $\times$ 7.5–13.5 μm , cylindrical to slightly narrowly fusoid, without any shorter elements at the base. CLAMP CONNECTIONS common in all tissues.

MATERIAL EXAMINED: PAKISTAN, KHYBER PAKHTUNKHWA, Khanspur, 2250 m a.s.l., solitary, on moist ground under *Abies pindrow*, 23 August 2010, A. Razaq K-40 (LAH 230840; GenBank HE863668).

Lepiota subincarnata J.E. Lange, Fl. agar. dan. 5 (Taxonomic Conspectus): V, 1940.

FIG. 2

PILEUS 4.0–4.2 cm diam., hemispherical to plano-convex, with obtuse to slightly umbonate central disc, white, with thick context, with reddish brown to pinkish brown scales on white background on central disc, fading towards margins; margins smooth, sometimes splitting open at maturity. LAMELLAE free, crowded, white to cream, ventricose, with 3–4 tiers of lamellulae, with wavy to denticulate edge. STIPE 5.5 × 0.8 cm, centrally attached, cylindrical, vinaceous red to pinkish brown, hollow; surface smooth to scaly with fibrillose type scales below annular zone. ODOUR none. TASTE not recorded.

BASIDIOSPORES 6–7.5 × 3.5–5 µm, $avl \times avw = 6.6 \times 4.3$ µm, $Q = 1.5$ –1.7; $avQ = 1.55$, oblong ellipsoid to ellipsoid to ovoid, colourless or pale yellow in 5% KOH, reddish brown in Melzer's reagent and strongly dextrinoid, smooth, thin-walled. BASIDIA 19.5–28.5 × 7–8.5 µm, 4-spored, occasionally 2-spored, subclavate to cylindrical, hyaline, thin-walled with oil contents. PLEUROCYSTIDIA absent. CHEILOCYSTIDIA 18–35.5 × 7–11.5 µm, hyaline, thin walled, subclavate to clavate. PILEUS COVERING a trichoderm with erect or ascending, hyaline to light brown, clamped terminal elements, 134–318 × 10.5–12.0 µm, cylindrical to slightly widened, with thickened apices, without any shorter elements at the base. CLAMP CONNECTIONS present in all tissues.

MATERIAL EXAMINED: PAKISTAN, KHYBER PAKHTUNKHWA, Khanspur, 2250 m a.s.l., solitary, on moist ground under *Abies pindrow*, 23 August 2010, A. Razaq KP-09 (LAH 230809; GenBank HE863669).

Discussion

Bon (1993), Vellinga (2001), and the authors before them attached much importance to basidiospore shape for infrageneric classification in *Lepiota*. Sect. *Lepiota*, sect. *Ovisporae*, and species in sect. *Stenosporae* share a trichodermal pileus covering but differ in spore shape: fusiform-amygdaliform in sect. *Lepiota*, ellipsoid to oblong in sect. *Ovisporae*, and with a spur in sect. *Stenosporae*. Vellinga (2003) discovered that sect. *Ovisporae* is polyphyletic and that in general the pileus covering is a more significant character for infrageneric delimitation than the spore shape. Bon (1993) and Vellinga (2003) dealt mostly with European species.

In our present analysis, we included all available ITS sequences from different parts of the world and recovered the same results (FIG. 3). Species with a trichodermal pileus covering with long and short elements cluster together in Clade 2 (FIG. 3). This clade corresponds to sect. *Lepiota* and subsect. *Felininae*.

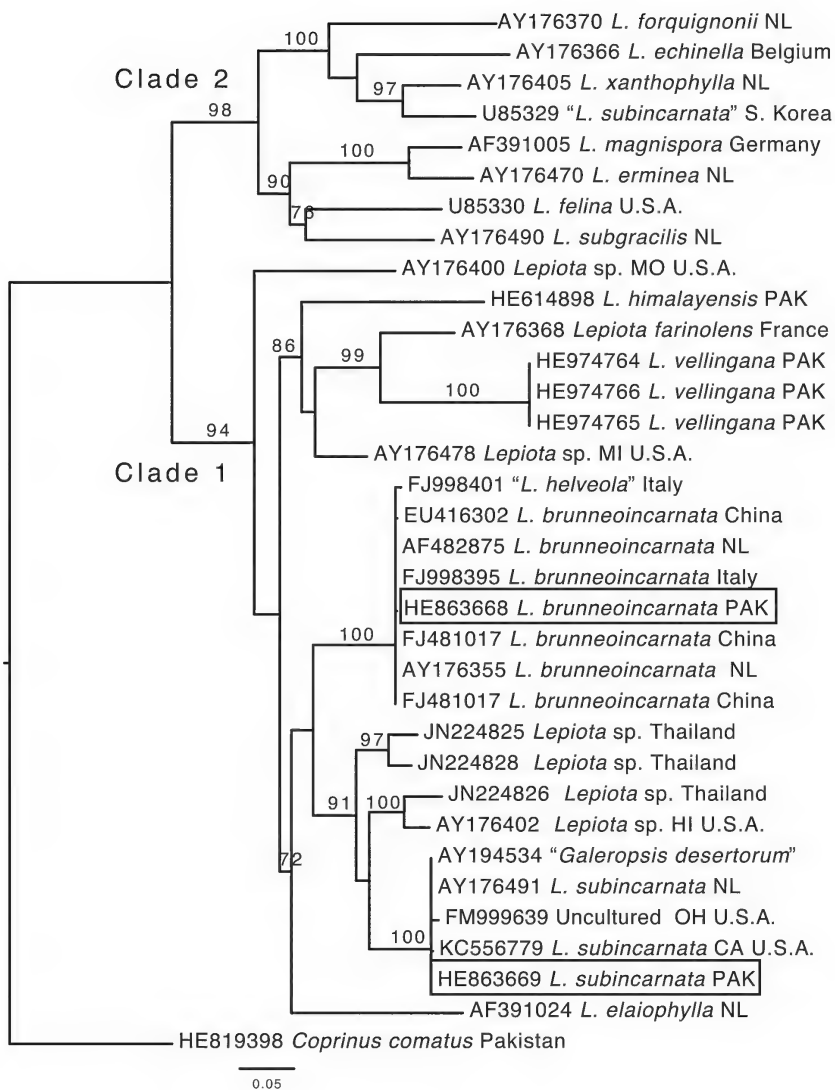


Fig. 3. Phylogenetic relationships of Pakistani collections of *L. brunneoincarnata* and *L. subincarnata* with other *Lepiota* species based on Maximum Likelihood analysis of nrITS sequences. Bootstrap values >70, based on 100 replicates shown at each node. The analysis involved 33 sequences with *Coprinus comatus* as outgroup. Names in quotation marks are discussed in the text. The two new Pakistani collections are outlined.

Species without these short pileus covering elements cluster in Clade 1, which corresponds to subsect. *Helveolinae*. The taxa in this clade are infamous for amatoxins (Vellinga 2003). Two recently described species from Pakistan — *L. himalayensis* Razaq & Khalid and *L. vellingana* Nawaz & Khalid — also cluster in Clade 1.

Both *L. brunneoincarnata* and *L. subincarnata* form well supported clades (both with 100% bootstrap support) and do not show any geographic structure, despite the fact that the sequences originate from very widely separated areas of Asia, Europe, and North America. It might be that ITS sequences alone are not sufficient, and data from other gene regions are needed to differentiate populations within the species.

Lepiota brunneoincarnata and *L. subincarnata* differ mainly in basidiocarp colours: *L. brunneoincarnata* has reddish brown or dark brown scales while *L. subincarnata* has nearly pinkish or vinaceous brown fine scales.

Lepiota brunneoincarnata from Pakistan, which clusters with isolates from Europe and China, is morphologically similar to European collections as described by Vellinga (2001). One GenBank sequence (FJ998401, labelled as *L. helveola* Bres.) falls within the *L. brunneoincarnata* clade, but the sequence is very short and it is likely that the specimen was misidentified.

The occurrence of *L. brunneoincarnata* in Pakistan suggests that it could be expected in other Asian countries; it is already known from China, based on sequence data, and from Israel (Kosakyan et al. 2008) and Turkey (Afyon & Yağiz 2004), based on morphological descriptions. This species is not yet known from North America, although a morphologically similar species was found in Ann Arbor (Michigan; GenBank AY176478).

The Pakistani collection of *L. subincarnata* is in close agreement with Vellinga's (2001) morphological description of Dutch collections. However, our collection is distinguished by longer pileal elements with thickened apices (11–20 µm), a difference that may be due to regional climate and geographical isolation.

In Asia, *Lepiota subincarnata* was previously known from Israel (Kosakyan et al. 2008) and from southwestern China (Yang 1990); the description of the Chinese material is similar to that of our Pakistani collection.

Kumar & Manimohan (2009) list *L. subincarnata* from Kerala, India, but their short description suggests a different species based on the dark brown colours and the pileus covering structure with short basal elements that are up to 400 µm long. A collection from South Korea identified as *L. subincarnata* (U85329; Johnson 1999) does not belong to *L. subincarnata* but falls among the Clade 2 species having a pileus trichoderm composed of longer and shorter cells (Fig. 1).

A sequence in GenBank (AY194534, labelled as *Galeropsis desertorum* Velen. & Dvořák), falls within the *L. subincarnata* clade. According to Hallen et al. (2003), this sequence is from a specimen collected in 1930 in Moravia (Czech Republic). It is possible that contamination or a laboratory mix-up might have caused this unexpected placement.

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New combinations in *Trichoderma* (Hypocreaceae, Hypocreales)

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ABSTRACT — Unitary nomenclature demands the use of a single name for pleomorphic fungi determined according to priority. For this reason combinations in *Trichoderma* are here provided for 46 species for which such a combination is lacking. Although many more such species are known, only those are included here that are dealt with in more recent papers and where some DNA data are available in GenBank, even if erroneous; for other species it is strongly recommended to consult databases like Index Fungorum or MycoBank. Information on types is provided for most species, and representative cultures, GenBank accessions for *tef1* and *rpb2*, and important references are given for all species.

KEY WORDS — anamorph, *Ascomycota*, ICN, Kew rule, pyrenomycetes, teleomorph

Introduction

Hypocrea Fr. 1825 is the type and name-giving genus of the *Hypocreaceae*, *Hypocreales*. However, its anamorphic counterpart, *Trichoderma* Pers. 1794 : Fr. is older. The Melbourne Code of Nomenclature (ICN) dictates a unitary nomenclature, i.e., the use of a single name for a pleomorphic fungus, no matter whether ana- or teleomorphic, based either on priority or on commission-sanctioned decisions. The species of *Hypocrea*/*Trichoderma* are monophyletic and this is to be expressed in a single generic name. *Trichoderma* has priority over *Hypocrea* and is commonly used in commercial applications, e.g., cellulase production by *T. reesei*. A poll of individuals interested in the subject was taken by the International Subcommittee on *Trichoderma* and *Hypocrea* (ISTH), which indicated a clear preference for adoption of *Trichoderma* over *Hypocrea*. Thus Rossman et al. (2013) proposed this generic name for acceptance by the Nomenclature Committee for Fungi (NCF) and the General Committee (GC) of the International Association for Plant Taxonomy (IAPT). However, a list of accepted names in *Trichoderma* has not yet been produced. There are some difficulties associated with this task. One example is the wide use

in commercial applications of *Trichoderma* epithets that are younger than the associated *Hypocrea* epithets, e.g., *T. reesei* / *H. jecorina* and *T. citrinoviride* / *H. schweinitzii*. Gams et al. (2012) suggested that authors establishing lists of protected names and the committees should apply the 'Kew rule' and accordingly "not recombine older epithets from a list-demoted genus into the list-accepted genus, when another one from pre-2013 is already available in that genus."

Index Fungorum lists 509 epithets in *Hypocrea*, including 55 names of varieties and forms (which have no priority at the species level). Many of these names do not represent members of this genus or are synonyms of other species of the genus, and the vast majority has never been re-assessed since their original description. Because of this large number of species names, it is strongly advisable for those who intend to describe new species to consult the Index of Fungi or databases like Index Fungorum or MycoBank, in order to avoid the creation of homonyms. At present, 219 *Trichoderma* epithets (including 9 varieties and forms) are listed in Index Fungorum. Many species have been re-assessed by several recent workers and others have been newly described in recent years. Jaklitsch et al. (2009, 2011), for example, established names in both *Hypocrea* and *Trichoderma* for species that are known to form an anamorph, but provided a name only in *Hypocrea* where no anamorph is known. In another example, Chaverri & Samuels (2003) did not establish names in *Trichoderma* for species earlier described in *Hypocrea* or for new species, where cultures did not survive storage. Such species as described in these works and several other recent papers (see below), are usually well characterized and also documented by molecular data. Therefore we provide here combinations in *Trichoderma* for these species as an intermediate step towards a list of accepted names in the genus *Trichoderma*.

The large number of species on one hand, the large number of isolates of many species on the other, and also the different portions of genes used as molecular-phylogenetic markers has made it difficult to select representative isolates and respective accessions for many species. For this reason we provide information on types, ex-type cultures, representative cultures and representative GenBank accessions for the most important markers, *rpb2* and *tef1*. We indicate also section or clade affinity for the species; when a formally established section is also supported by molecular phylogeny, we give preference to that designation.

Materials & abbreviations

All publications on the taxonomy and phylogeny of *Hypocrea* and/or *Trichoderma* that include molecular data were consulted and for species lacking an epithet in *Trichoderma*, information on types, ex-type or representative cultures was extracted. GenBank accessions for representative cultures were retrieved from the NCBI homepage (<http://www.ncbi.nlm.nih.gov/>). The following abbreviations are used in the

text: n.a. = not available, n.d. = not determined; phylog. = phylogenetic affinity; repres. = representative; sect. = section.

Results – data arrangement

New combinations in *Trichoderma* are proposed for *Hypocrea* names in species where such a combination is lacking. The 46 species treated here are (1) 41 for which DNA data are available and (2) 5 that are included because of confusing data. Additional data are given as: type information; repres. cultures; phylog. clade or section (plus short information on (atypical) anamorphs deviating from *Trichoderma* that form green conidia); repres. GenBank sequence accessions; important (recent) references.

Trichoderma albocorneum (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.**

MYCOBANK MB807413

≡ *Hypocrea albocornea* Yoshim. Doi, Bull. natn. Sci. Mus., Tokyo 15: 712 (1972).

HOLOTYPE: TNS-F-190171, ex-type culture: n.a.; possibly repres.: G.J.S. 97-28 (*tef1*: AY937440).

PHYLOG.: unknown; species with green ascospores. REFERENCES: Doi (1972), Chaverri & Samuels (2003).

Trichoderma albofulvum (Berk. & Broome) Jaklitsch & Voglmayr, **comb. nov.**

MYCOBANK MB807414

≡ *Hypocrea albofulva* Berk. & Broome, J. Linn. Soc., Bot. 14: 113 (1873).

HOLOTYPE: n.d.; ex-type culture: n.a. The species is similar to *T. ochroleucum*.

PHYLOG.: sect. *Trichoderma*. NOTE: The species was described from Sri Lanka. The strains G.J.S. 01-234 (*tef1* accession: DQ846668) and/or G.J.S. 01-265 (*rpb2* accession: DQ835524) from material collected in Thailand may represent this species (see Jaklitsch 2011).

Trichoderma alcalifuscens (Overton) Jaklitsch & Voglmayr, **comb. nov.**

MYCOBANK MB807415

≡ *Hypocrea alcalifuscens* Overton, in Overton, Stewart & Geiser, Stud. Mycol. 56: 62 (2006).

HOLOTYPE: BPI 843638; isotype TAA(M) 181548; ex-type culture: CBS 122303 = TFC 2000-36.

Phylog.: unnamed clade; 'basal'; anamorph verticillium-like, conidia hyaline. REPRESENTS: *tef1*: FJ860610; *rpb2*: DQ834462. REFERENCE: Overton et al. (2006a), Jaklitsch (2011).

Trichoderma americanum (Canham) Jaklitsch & Voglmayr, **comb. nov.**

MYCOBANK MB807416

≡ *Hypocrea citrina* var. *americana* Canham, Mycologia 61: 320 (1969).

≡ *Hypocrea americana* (Canham) Overton, in Overton, Stewart, Geiser & Jaklitsch, Stud. Mycol. 56: 21 (2006).

HOLOTYPE: NY ex CUP 38045; ex-type culture: ATCC 18574; other repres. strains: CBS 123072 = G.J.S. 92-93, G.J.S. 96-191.

PHYLOG.: sect. *Hypocreanum*; anamorph acremonium-like, conidia hyaline. REPRESENTS: SEQUENCES: *tef1*: DQ835435 + DQ005523 + DQ835489; *rpb2*: DQ835455. REFERENCE: Overton et al. (2006a).

***Trichoderma andinense* (Samuels & Petrini) Samuels, Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807417

≡ *Hypocrea andinensis* Samuels & Petrini, in Samuels, Petrini, Kuhls, Lieckfeldt & Kubicek, Stud. Mycol. 41: 13 (1998).

HOLOTYPE: BPI 1109854; ex-type culture: CBS 345.97 = G.J.S. 90-140 = ATCC 208857.

PHYLOG.: sect. *Longibrachiatum*. REPRESENTS: SEQUENCES: *tef1*: AY956321; *rpb2*: JN175531. REFERENCES: Samuels et al. (1998, 2012).

***Trichoderma atrogelatinosum* (Dingley) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807418

≡ *Hypocrea atrogelatinosa* Dingley, Trans. Roy. Soc. New Zealand 83: 645 (1956).

HOLOTYPE: PDD 10471; ex-type culture: n.a..

REFERENCE: Chaverri & Samuels (2003). NOTE: Status unclear. Several accessions are deposited in GenBank under the name *Hypocrea atrogelatinosa*; *rpb2* sequences (strains G.J.S. 88-28, 89-136, and 95-159) as well as *tef1* exon sequences belong to *T. ceraceum* (*H. ceracea*); however, *tef1* intron sequences vary considerably among these isolates.

***Trichoderma avellaneum* (Rogerson & S.T. Carey) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807419

≡ *Hypocrea avellanea* Rogerson & S.T. Carey, in Carey & Rogerson, Brittonia 28: 381 (1976).

HOLOTYPE: NY (MEBB 2471); isotype in K; ex-type culture: n.a.; repres. strain CBS 121667 = C.T.R. 77-155.

PHYLOG.: unknown, 'basal'; anamorph verticillium-like, conidia hyaline. REPRESENTS: SEQUENCES: *tef1*: AY225857; *rpb2*: AF545562. REFERENCE: Carey & Rogerson (1976).

***Trichoderma brittdaniae* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807420

≡ *Hypocrea brittdaniae* Jaklitsch & Voglmayr, Mycologia 104: 1216 (2012).

HOLOTYPE: K(M) 89878; ex-type culture: n.a. (ascospores not germinating).

PHYLOG.: sister to sect. *Longibrachiatum*; anamorph unknown. REPRESENTS: SEQUENCES (from stromata): *tef1*: JQ685865; *rpb2*: JQ685881. REFERENCE: Jaklitsch & Voglmayr (2012).

***Trichoderma caerulescens* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807422

≡ *Hypocrea caerulescens* Jaklitsch & Voglmayr, in Jaklitsch, Stadler & Voglmayr, Mycologia 104: 928 (2012).

HOLOTYPE: WU 31600; ex-type culture: CBS 130011 = S195.

PHYLOG.: sect. *Trichoderma*. REPRESENTS: SEQUENCES: *tef1*: JN715621; *rpb2*: JN715604. REFERENCE: Jaklitsch et al. (2012).

***Trichoderma citrinum* (Pers. : Fr.) Jaklitsch, W. Gams & Voglmayr, comb. nov.**

MYCOBANK MB807423

≡ *Sphaeria citrina* Pers., *Observ. mycol. (Lipsiae)* 1: 68 (1796) : Fr.≡ *Hypocrea citrina* (Pers. : Fr.) Fr., *Summa veg. Scand.*,

Section Post. (Stockholm): 383 (1849)

= *Sphaeria lactea* Fr., *Kongl. Vetensk. Acad. Handl.*, n.s. 37: 141 (1816) : Fr.≡ *Hypocrea lactea* (Fr. : Fr.) Fr., *Summa veg. Scand.*, Section Post.: 383 (1849).≡ *Trichoderma lacteum* (Fr. : Fr.) Bissett, *Canad. J. Bot.* 69: 2367 (1992 ["1991"]).

NEOTYPE of *Trichoderma citrinum*: W. Gams 4031 (CBS); ex-type culture: CBS 894.85. Holotype of *Trichoderma lacteum*: DAOM 167644; ex-type culture CBS 853.70. EPITYPE of *Trichoderma lacteum*, **here designated**: W. Gams 4031 (CBS); ex-epitype culture: CBS 894.85.

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tef1*: FJ860631, DQ835441; *rpb2*: FJ179603, AF545561. REFERENCES: Overton et al. (2006a), Jaklitsch (2011).

NOTE: *Hypocrea citrina* is a well-known name for a well-known species, particularly in Europe, and has priority over *H. lactea*. Bissett (1992) erected the name *Trichoderma lacteum* for the anamorph of *H. lactea*. The *tef1* intron 5 of its ex-type strain CBS 853.70 clearly demonstrates conspecificity of *T. lacteum* with *T. citrinum*. The revised citation of *T. lacteum*, above, follows the working practice advocated by Hawksworth et al. (2013). Application of the 'Kew rule' would favour *T. lacteum* as the appropriate *Trichoderma* name for a synonymised *H. citrina*/*H. lactea*. However, this would be undesirable, because the inconsistent application of the name *H. lactea* to a number of different taxa could be misleading; for example, "*Hypocrea lactea*" sensu Doi (1972) was recently described as *T. pseudolacteum* by Kim et al. (2013).

***Trichoderma corneum* (Pat.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807424

≡ *Hypocrea cornea* Pat., *J. Bot. (Morot)*: 64 (1890).

HOLOTYPE: K; ex-type culture: n.a.

The cultures G.J.S. 97-82 (*tef1*: AY937435), G.J.S. 97-75 (*tef1*: AY937431) and G.J.S. 97-90 (*tef1*: AY937426) are isolates from specimens collected in Thailand. As the GenBank *tef1* accessions for these isolates vary considerably, fresh material from the original collecting region Tonkin, Vietnam, is necessary to judge which of them match the species. PHYLOG.: unclear; species with green ascospores. REFERENCE: Chaverri & Samuels (2003).

***Trichoderma costaricense* (P. Chaverri & Samuels) P. Chaverri, Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807425

≡ *Hypocrea costaricensis* P. Chaverri & Samuels, *Stud. Mycol.* 48: 58 (2003).

HOLOTYPE: INB 0003527695; ex-type culture: P.C. 21 (lost after determination of DNA data).

PHYLOG.: Chlorospora clade, species with green ascospores. REPRES. SEQUENCES: *tef1*: AY737741 + AY391980; *rpb2*: AY391921. REFERENCE: Chaverri & Samuels (2003).

***Trichoderma danicum* (Jaklitsch) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807426

≡ *Hypocrea danica* Jaklitsch, Stud. Mycol. 63: 41 (2009).

HOLOTYPE: WU 29046; ex-type culture: CBS 121273 = C.P.K. 2448 = Hypo 402.

PHYLOG.: Spinulosa clade, species with green ascospores; anamorph not formed.

REPRES. SEQUENCES: *tef1*: FJ860634; *rpb2*: FJ860534. REFERENCE: Jaklitsch (2009).

***Trichoderma decipiens* (Jaklitsch, K. Pöldmaa & Samuels) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807427

≡ *Hypocrea decipiens* Jaklitsch, K. Pöldmaa & Samuels, Mycologia 100: 981 (2008).

HOLOTYPE: BPI 747356; ex-type culture: CBS 121307 = G.J.S. 97-207; repres. G.J.S. 91-101.

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tef1*: FJ860635, EF550995; *rpb2*: DQ835520. REFERENCES: Jaklitsch et al. (2008), Overton et al. (2006b; as *Hypocrea farinosa*). Some further accessions can be retrieved under the name "*Hypocrea farinosa*", because the name has not been updated, pending consent by B. Overton.

***Trichoderma eucorticoides* (Overton) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807428

≡ *Hypocrea eucorticoides* Overton, in Overton, Stewart & Geiser, Stud. Mycol. 56: 55 (2006).

HOLOTYPE: LPS 1719; ex-type culture: n.a.; repres. G.J.S. 99-61 (lost).

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tef1*: DQ835502 + DQ835474; *rpb2*: DQ835518. REFERENCE: Overton et al. (2006b).

***Trichoderma flaviconidium* (P. Chaverri, Druzhin. & Samuels) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807429

≡ *Hypocrea flaviconidia* P. Chaverri, Druzhin. & Samuels, in Druzhinina, Chaverri, Fallah, Kubicek & Samuels, Stud. Mycol. 50: 404 (2004).

HOLOTYPE: INB 3862698; isotype BPI 746538; ex-type culture: G.J.S. 99-51 (dead); repres. G.J.S. 99-49, CBS 116238 = G.J.S. 99-57.

PHYLOG.: sect. *Trichoderma*, Hamatum subclade. REPRES. SEQUENCES: *tef1*: DQ020001, AY665711; *rpb2*: EU883557. REFERENCE: Druzhinina et al. (2004).

***Trichoderma flavipes* (Peck) Seifert, Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807430

≡ *Stilbum flavipes* Peck, Ann. Rep. N.Y. St. Mus. nat. Hist. 31: 45 (1879 ["1877"]).

≡ *Stilbella flavipes* (Peck) Seifert, Stud. Mycol. 27: 68 (1985).

= *Hypocrea cinereoflava* Samuels & Seifert, in Seifert & Samuels, Mycologia 89: 515 (1997).

HOLOTYPE of *Stilbum flavipes*: NYS; holotype of *Hypocrea cinereoflava*: BPI 802847; ex-teleotype culture: G.J.S. 92-102 = DAOM 222357.

PHYLOG.: unnamed clade, 'basal'; anamorph synnematos, stilbella-like in nature, conidia green. REPRES. SEQUENCES: *tef1*: DQ834454; *rpb2*: DQ834461. REFERENCE: Seifert & Samuels (1997); additional synonyms given in this publication.

Trichoderma foliicola* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.*

MYCOBANK MB807431

≡ *Hypocrea foliicola* Jaklitsch & Voglmayr, *Mycologia* 104: 1218 (2012).

HOLOTYPE: WU 31611; ex-type culture: CBS 130008 = Hypo 645.

PHYLOG.: *Pachybasium* Core Group, conidia hyaline. REPRES. SEQUENCES: *tef1*: JQ685862; *rpb2*: JQ685876. REFERENCE: Jaklitsch & Voglmayr (2012).

Trichoderma hispanicum* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.*

MYCOBANK MB807432

≡ *Hypocrea hispanica* Jaklitsch & Voglmayr, in Jaklitsch, Stadler & Voglmayr, *Mycologia* 104: 935 (2012).

HOLOTYPE: WU 31606; ex-type culture: CBS 130540 = S453.

PHYLOG.: sect. *Trichoderma*. REPRES. SEQUENCES: *tef1*: JN715659; *rpb2*: JN715600. REFERENCE: Jaklitsch et al. (2012).

Trichoderma hunua* (Dingley) Jaklitsch & Voglmayr, **comb. nov.*

MYCOBANK MB807433

≡ *Hypocrea hunua* Dingley, *Trans. & Proc. Roy. Soc. New Zealand* 79(3–4): 327 (1952).

HOLOTYPE: PDD 10455; ex-type culture: n.a.; repres. CBS 238.63 (isolated: Dingley, No. 5).

PHYLOG.: *Semiorbis* clade. REPRES. SEQUENCES: *tef1*: AF401011; *rpb2*: n.a. REFERENCE: Kullnig-Gradinger et al. (2002).

Trichoderma lacuwombatense* (B.S. Lu, Druzhin. & Samuels) Jaklitsch & Voglmayr, **comb. nov.*

MYCOBANK MB807434

≡ *Hypocrea lacuwombatensis* B.S. Lu, Druzhin. & Samuels, in Lu, Druzhinina, Fallah, Chaverri, Gradinger, Kubicek & Samuels, *Mycologia* 96: 338 (2004).

HOLOTYPE: PDD 77489; isotype BPI 746621; ex-type culture: CBS 122668 = G.J.S. 99-198.

PHYLOG.: *Pachybasium* Core Group. REPRES. SEQUENCES: *tef1*: AY937452; *rpb2*: n.a. REFERENCE: Lu et al. (2004).

Trichoderma megalocitrinum* (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.*

MYCOBANK MB807435

≡ *Hypocrea megalocitrina* Yoshim. Doi, *Bull. natn. Sci. Mus., Tokyo* 15: 669 (1972).

HOLOTYPE: TNS-F-223220; isotype in NY; ex-type culture: n.a.; repres. BEO 00-09.

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tef1*: AY225855 (exon); *rpb2*: AF545563. REFERENCE: Overton et al. (2006a).

Trichoderma microcitrinum* (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.*

MYCOBANK MB MB807436

≡ *Hypocrea microcitrina* Yoshim. Doi, *Bull. natn. Sci. Mus., Tokyo* 15: 667 (1972).

HOLOTYPE: TNS-F-223325; ex-type culture: n.a.; repres. BPI 744660; repres. cultures G.J.S. 97-248, G.J.S. 91-61.

PHYLOG.: sect. *Hypocreanum*; anamorph acremonium- to verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tef1*: DQ835449 + DQ835479; *rpb2*: DQ835462. REFERENCE: Overton et al. (2006a).

***Trichoderma neorufum* (Samuels, Dodd & Lieckf.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807437

≡ *Hypocrea neorufa* Samuels, Dodd & Lieckf., in Dodd, Lieckfeldt, Chaverri, Overton & Samuels, Mycol. Prog. 1: 421 (2002).

HOLOTYPE: BPI 744493; ex-type culture: CBS 111144 = G.J.S. 96-135; repres. CBS 119498.

PHYLOG.: sect. *Trichoderma*. REPRES. SEQUENCES: *tef1*: FJ860653; *rpb2*: FJ860550. REFERENCES: Dodd et al. (2002), Jaklitsch (2011).

***Trichoderma novae-zelandiae* (Samuels & Petrini) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807438

≡ *Hypocrea novae-zelandiae* Samuels & Petrini, in Samuels, Petrini, Kuhls, Lieckfeldt & Kubicek, Stud. Mycol. 41: 25 (1998).

HOLOTYPE: PDD 46792; ex-type cultures: CBS 496.97 and CBS 639.92 = G.J.S. 81-265 = ATCC 208856.

PHYLOG.: sect. *Longibrachiatum*. REPRES. SEQUENCES: *tef1*: AY865639, AY937448; *rpb2*: JN133563. REFERENCES: Samuels et al. (1998, 2012), Druzhinina et al. (2012).

***Trichoderma nybergianum* (T. Ulvinen & H.L. Chamb.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807439

≡ *Hypocrea nybergiana* T. Ulvinen & H.L. Chamb., in Chamberlain, Rossman, Stewart, Ulvinen & Samuels, Karstenia 44: 21 (2004).

HOLOTYPE: OULU F 49597; isotype OULU F 49596; ex-type culture: n.a.; repres. CBS 122500 = C.P.K. 3159 = Hypo 572, CBS 122496 = C.P.K. 3163 = Hypo 577.

PHYLOG.: *Pachybasium* Core Group, conidia hyaline. REPRES. SEQUENCES: *tef1*: FJ179575; *rpb2*: FJ179611. REFERENCES: Chamberlain et al. (2004), Jaklitsch (2011).

***Trichoderma ochroleucum* (Berk. & Ravenel) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807440

≡ *Hypocrea ochroleuca* Berk. & Ravenel, in Berkeley, Grevillea 4: 14 (1875).

HOLOTYPE: K(M) 56075; ex-type culture: n.a.; repres. CBS 119502 = C.P.K. 1895 = Hypo 274.

PHYLOG.: sect. *Trichoderma*. REPRES. SEQUENCES: *tef1*: FJ860659; *rpb2*: FJ860556. REFERENCE: Jaklitsch (2011). NOTE: GenBank accessions for G.J.S. 01-234 and G.J.S. 01-265 may represent *Trichoderma albofulvum* (see above).

Trichoderma orientale* (Samuels & Petrini) Jaklitsch & Samuels, *comb. nov.

MYCOBANK MB807441

≡ *Hypocrea orientalis* Samuels & Petrini, in Samuels, Petrini, Kuhl, Lieckfeldt & Kubicek, Stud. Mycol. 41: 30 (1998).

HOLOTYPE: BPI 1109853; ex-type culture: CBS 130428 = G.J.S. 88-81, repres. CBS 131488, G.J.S. 09-784.

PHYLOG.: sect. *Longibrachiatum*. REPRES. SEQUENCES: *tef1*: EU401581, JN175573, JQ685868; *rpb2*: JN175522, JQ685884. REFERENCES: Samuels et al. (1998, 2012).

Trichoderma parapiluliferum* (B.S. Lu, Druzhin. & Samuels) Jaklitsch & Voglmayr, *comb. nov.

MYCOBANK MB807442

≡ *Hypocrea parapilulifera* B.S. Lu, Druzhin. & Samuels, in Lu, Druzhinina, Fallah, Chaverri, Gradinger, Kubicek & Samuels, Mycologia 96: 331 (2004).

HOLOTYPE: BPI 112832; ex-type culture: CBS 112771 = G.J.S. 91-60; repres. CBS 120921 = C.P.K. 1908.

PHYLOG.: *Pachybasium* Core Group, conidia hyaline. REPRES. SEQUENCES: *tef1*: FJ179578, AY937444; *rpb2*: FJ179614. REFERENCES: Lu et al. (2004), Jaklitsch (2011).

Trichoderma parmastoi* (Overton) Jaklitsch & Voglmayr, *comb. nov.

MYCOBANK MB807443

≡ *Hypocrea parmastoi* Overton, in Overton, Stewart & Geiser, Stud. Mycol. 56: 62 (2006).

HOLOTYPE: BPI 843639; isotype TAA(M) 169055; ex-type culture: TFC 97-143; repres. CBS 121139.

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tef1*: FJ860668, DQ834456 (exon); *rpb2*: FJ860567, DQ834463. REFERENCES: Overton et al. (2006b), Jaklitsch (2011).

Trichoderma patella* (Cooke & Peck) Jaklitsch & Voglmayr, *comb. nov.

MYCOBANK MB807444

≡ *Hypocrea patella* Cooke & Peck, in Peck, Ann. Rep. N.Y. St. Mus. nat. Hist. 29: 57 (1878 ["1875"]).

HOLOTYPE: NYS; isotype: BPI 631626; ex-type culture: n.a.; repres. CBS 110082 = G.J.S. 95-173, CBS 110084 = G.J.S. 96-198 = ATCC 208855.

PHYLOG.: unknown, remotely associated with sect. *Longibrachiatum*. REPRES. SEQUENCES: *tef1*: AY937428; *rpb2*: n.a.. REFERENCE: Dodd et al. (2002).

Trichoderma peltatum* (Berk.) Samuels, Jaklitsch & Voglmayr, *comb. nov.

MYCOBANK MB807511

≡ *Sphaeria peltata* Jungh., Verh. Batav. Genootsch. Kunst. Wet. 17(3): 20 (1838), nom. illegit., non DC. 1805.

≡ *Hypocrea peltata* Berk., Hooker's J. Bot. Kew Gard. Misc. 3: 205 (1851).

HOLOTYPE: L 00532089 (Junghuhn 103); ex-type culture: n.a.; repres. CBS 127107 = G.J.S. 09-1550, CBS 127115 = G.J.S. 08-207, G.J.S. 10-103, G.J.S. 10-104, G.J.S. 10-105, CBS 120951.

PHYLOG.: unnamed clade, close to *T. sambuci* and *T. tremelloides*; anamorph not formed. REPRESENTATION: *tef1*: n.a.; *rpb2*: HQ260609, HQ260610. REFERENCE: Samuels & Ismaiel (2011).

NOTE: The original name of this taxon, *Sphaeria peltata*, is an illegitimate later homonym and cannot act as basionym for new combinations (ICN Art. 6.10). The basionym is the earliest legitimate name, *Hypocrea peltata* Berk. 1851, which is to be treated as a replacement name for the illegitimate *S. peltata* (ICN 58.1).

***Trichoderma pezizoides* (Berk. & Broome) Samuels, Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807445

≡ *Hypocrea pezizoides* Berk. & Broome, J. Linn. Soc., Bot. 14(74): 112 (1873).

HOLOTYPE: n.d.; ex-type culture: n.a.; ?repres.: CBS 101131 = G.J.S. 97-83 = C.P.K. 775, G.J.S. 01-231 (Thailand). Originally described from Sri Lanka.

PHYLOG.: sect. *Trichoderma*. REPRESENTATION: *tef1*: AY225859; *rpb2*: JN715610, AF545564. REFERENCE: Atanasova et al. (2013).

***Trichoderma protopulvinatum* (Yoshim. Doi) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807446

≡ *Hypocrea protopulvinata* Yoshim. Doi, Bull. natn. Sci. Mus., Tokyo 15: 695 (1972).

HOLOTYPE: TNS-F-223421; isotype NY 00965650; ex-type culture: CBS 739.83; repres. C.P.K. 2434, CBS 121274 = C.P.K. 2430.

PHYLOG.: sect. *Hypocreanum*; anamorph acremonium-like, conidia hyaline. REPRESENTATION: *tef1*: FJ860676; *rpb2*: FJ860574. REFERENCES: Overton et al. (2006a), Jaklitsch (2011).

***Trichoderma pulvinatum* (Fuckel) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807447

≡ *Hypocrea pulvinata* Fuckel, Jb. nassau. Ver. Naturk. 23–24: 185 (1870).

LECTOTYPE: FH 00284789 (Fuckel 876); ex-type culture: n.a.; repres. CBS 121279.

PHYLOG.: sect. *Hypocreanum*; anamorph acremonium- to verticillium-like, conidia hyaline. REPRESENTATION: *tef1*: FJ860683; *rpb2*: FJ860577. REFERENCES: Overton et al. (2006a), Jaklitsch (2011).

***Trichoderma rhododendri* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807448

≡ *Hypocrea rhododendri* Jaklitsch & Voglmayr, in Jaklitsch, Fungal Diversity 48: 199 (2011).

HOLOTYPE: WU 29442 (Hypo 209); ex-type culture: CBS 119288 = C.P.K. 2015.

PHYLOG.: Psychrophila clade, anamorph unknown. REPRESENTATION: *tef1*: FJ860685; *rpb2*: FJ860578. REFERENCE: Jaklitsch (2011).

***Trichoderma rodmanii* (Samuels & P. Chaverri) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807449

≡ *Hypocrea rodmanii* Samuels & P. Chaverri, Mycol. Prog. 7: 213 (2008).

HOLOTYPE: BPI 1112859; ex-type culture: CBS 120895 = G.J.S. 91-88; repres. CBS 121553.

PHYLOG.: Brevicompactum clade. REPRES. SEQUENCES: *tef1*: FJ860687, EU338286; *rpb2*: FJ860580, EU338324. REFERENCES: Degenkolb et al. (2008), Jaklitsch (2011).

***Trichoderma sambuci* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807450

≡ *Hypocrea sambuci* Jaklitsch & Voglmayr, in Jaklitsch, Fungal Diversity 48: 213 (2011).

HOLOTYPE: WU 29463 (Hypo 198); ex-type culture: n.a.; repres. CBS 126958 = S 94.

PHYLOG.: unnamed clade, close to *T. tremelloides*; conidia hyaline. REPRES. SEQUENCES (based on DNA from the specimen WU 29467 = Hypo 426): *tef1*: FJ860693; *rpb2*: FJ860585. REFERENCE: Jaklitsch (2011).

***Trichoderma semiorbis* (Berk.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807451

≡ *Sphaeria semiorbis* Berk., J. Bot. (Hooker) 2: 146 (1840).

≡ *Hypocrea semiorbis* (Berk.) Berk., in Hooker, Fl. Tasman. 2: 278. (1859 [“1860”]).

HOLOTYPE: K; ex-type culture: n.a.; repres. CBS 244.63 = DAOM 167636, G.J.S. 99-108, G.J.S. 99-109.

PHYLOG.: Semiorbis clade; conidia hyaline. REPRES. SEQUENCES: *tef1*: AF545568; *rpb2*: JN133567, AF545522. REFERENCE: Chaverri et al. (2003).

***Trichoderma spinulosum* (Fuckel) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807452

≡ *Hypocrea spinulosa* Fuckel, Jb. nassau. Ver. Naturk. 23–24: 184 (1870).

HOLOTYPE: Fuckel (G); ex-type culture: n.a.; repres. CBS 310.50, CBS 311.50 = C.P.K. 1510, CBS 121272 = C.P.K. 2464.

PHYLOG.: Spinulosa clade, species with green ascospores; anamorph not formed. REPRES. SEQUENCES: *tef1*: FJ860701; *rpb2*: FJ860591. REFERENCES: Chaverri & Samuels (2003), Jaklitsch (2009).

***Trichoderma stellatum* (B.S. Lu, Druzhin. & Samuels) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807453

≡ *Hypocrea stellata* B.S. Lu, Druzhin. & Samuels, in Lu, Druzhinina, Fallah, Chaverri, Gradinger, Kubicek & Samuels, Mycologia 96: 333 (2004).

HOLOTYPE: PDD 77488; ex-type culture: CBS 112265 = G.J.S. 99-122 (as ‘G.J.S. 99-222’ in GenBank).

PHYLOG.: Pachybasium Core Group, conidia hyaline. REPRES. SEQUENCES: *tef1*: AY937445, AY240855 (intron5 only); *rpb2*: n.a. REFERENCE: Lu et al. (2004).

***Trichoderma subsulphureum* (Syd.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807454

≡ *Hypocrea subsulphurea* Syd., in De Wildeman, Études Fl. Bas- Moyen-Congo 3: 15 (1909).

HOLOTYPE: ?lost; ex-type culture: n.a.; ?repres. M141 (?BPI).

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES (from teleomorph of M141): *tef1*: DQ835492; *rpb2*: DQ835522. REFERENCE: Overton et al. (2006b).

***Trichoderma sulawesense* (Yoshim. Doi) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807455

≡ *Hypocrea sulawesensis* Yoshim. Doi, in Samuels, Doi & Rogerson, Mem. N. Y. bot. Gdn 59: 23 (1990).

HOLOTYPE: BO; isotypes NY 01169121, NY 00967625, TNS-F-243769, ex-type culture: G.J.S. 2006 (lost), repres. G.J.S. 85-228.

PHYLOG.: unnamed clade; species with green ascospores; anamorph forming elongate hyaline phragmoconidia in addition to green unicellular conidia. REPRES. SEQUENCES: *tefl*: AY737730 + AY392002; *rpb2*: AY391954. REFERENCE: Chaverri & Samuels (2003).

***Trichoderma sulphureum* (Schwein.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807456

≡ *Sphaeria sulphurea* Schwein., Trans. Amer. philos. Soc., Ser. 2, 4 (2): 193 (1832).

≡ *Hypocrea sulphurea* (Schwein.) Sacc., Syll. Fung. (Abellini) 2: 535 (1883).

HOLOTYPE: n.d.; isotype: K, ex herb Schweinitz; not epitypified; ex-type culture: n.a.; repres. C.P.K. 1593, CBS 119929 = C.P.K. 1598.

PHYLOG.: sect. *Hypocreanum*; anamorph acremonium- to verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tefl*: FJ860709; *rpb2*: FJ860599. REFERENCES: Overton (2006b), Jaklitsch (2011).

***Trichoderma victoriense* (Overton) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807457

≡ *Hypocrea victoriensis* Overton, in Overton, Stewart & Geiser, Stud. Mycol. 56: 55 (2006).

HOLOTYPE: BPI 747361; ex-type culture: G.J.S. 99-200; repres. C.P.K. 3565.

PHYLOG.: sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. REPRES. SEQUENCES: *tefl*: FJ860718; *rpb2*: DQ835517. REFERENCE: Overton et al. (2006b).

***Trichoderma virescentiflavum* (Speg.) Jaklitsch & Voglmayr, comb. nov.**

MYCOBANK MB807458

≡ *Hypocrea virescentiflava* Speg., Boln Acad. nac. Cienc. Córdoba 11: 529 (1889).

HOLOTYPE: LPS 1726 (J. Puiggari 2353), ex-type culture: n.a.; repres. P.C. 278 (lost after determination of DNA data).

PHYLOG.: *Virescentiflava* clade, species with green ascospores. REPRES. SEQUENCES: *tefl*: AY737749 + AY392007; *rpb2*: AY391959. REFERENCE: Chaverri & Samuels (2003).

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***Lactarius* taxa by Zdeněk Schaefer –
types and other collections in PRM**

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ABSTRACT— Extant PRM herbarium vouchers of *Lactarius* taxa described, validated, or neotypified by Zdeněk Schaefer are enumerated and discussed. For each taxon, the holotype, paratypes, other original materials, and later collected specimens identified or revised by Schaefer are cited. The nomenclatural status of each taxon is evaluated and information from published revisions/discussions is summarized. These data provide a basis both for thorough revisions by classical and molecular methods and for future lecto- or neotypifications. Such revisions are encouraged because some of Schaefer's taxa (e.g., *L. albocremeus*) may represent good species while others should clearly be synonymized with earlier published taxa. Currently accepted taxa are *L. pilatii* and *L. bertillonii* ($\equiv$ *Lactifluus bertillonii*).

KEY WORDS—*Basidiomycota*, *Russulales*, taxonomy, nomenclature, Europe

Introduction

Zdeněk Schaefer (1906–1974), a chemical engineer in the glass industry, was a Czech amateur mycologist who became interested in fungi in 1936. In 1945 he decided to focus on *Lactarius* (Herink 1977), eventually publishing 29 works on the genus, mostly in the leading Czech journal, ČESKÁ MYKOLOGIE (now CZECH MYCOLOGY). For his biographies and bibliographies, see Pouzar (1966) and Herink (1977). Schaefer was known for his detailed approach and his narrow species concept. Material studied by him is now stored in the mycological herbaria of the National Museum in Prague (PRM), the Moravian Museum in Brno (BRNM), and (rarely) in the Slovak National Museum in Bratislava (BRA). After his death, his family threw away his personal herbarium (including some types; Z. Pouzar, pers. comm. 2013) because of insect infestation; consequently, only a small part of his collection is conserved in PRM (mostly collections from earlier periods of Schaefer's work).

In the late 1960s, Schaefer prepared a Czech-language monograph of Czechoslovakian *Lactarius* species. However, the work remained unpublished because of political restrictions following the 1968 “Prague spring” and Soviet occupation. The original typewritten manuscript, accompanied by Schaefer’s coloured pencil drawings of *Lactarii*, is deposited in the Museum of Eastern Bohemia in Hradec Králové (HR), and photocopies are available in PRM and BRNM. He had planned to publish about 70 new taxa (species, varieties, forms) in his monograph.

Schaefer published more than 20 new taxa of *Lactarius* (species and varieties) in various papers (1948, 1956, 1957, 1958, 1960, 1966, 1968, 1970, 1972, 1979), the last of which (Schaefer 1979) was prepared from his unpublished paper by the ČESKÁ MYKOLOGIE Editorial Board (Z. Pouzar, pers. comm. 2013) and published five years after his death. In other papers Schaefer also validated names published by Smotlacha (1947) and Neuhoﬀ (1956) and designated a neotype for a 1920 Velenovský name. Schaefer’s new taxa, which might represent real species or varieties, need a thorough revision. The only broadly focused revision was done by Basso (1999), who used only a part of the available vouchers.

Our intention here is to clarify which types, other original materials, and later collections identified by Schaefer are stored in PRM. Taxa supported by these vouchers can be studied both by classical and DNA methods, which is important for further development of *Lactarius* taxonomy. A paper devoted to collections in BRNM should be prepared by local curators.

Materials & methods

Only published *Lactarius* taxa (both valid and invalid names) by Schaefer are included. They are arranged alphabetically under *Lactarius*, including two recent synonyms in *Lactifluus*. New taxa proposed in Schaefer’s unpublished monograph (see Introduction) are omitted, as they are not published effectively. Each entry starts with bibliographic data on the Latin, Czech, and/or German descriptions. As Schaefer’s publications are poorly arranged and tend to confine detailed information to the Czech text, we compiled and translated the important voucher data to English. The following materials from PRM are cited for each taxon: holotype, paratypes, other original materials (not cited with all details in the protologue but certainly used for its preparation), and other collected specimens subsequently identified or revised by Schaefer. The localities are given not in their original form but are amended based on data accumulated from herbarium labels, Latin descriptions, and Czech or German descriptions/discussions and supplemented with current geographic data. Taxonomic and nomenclatural terms are in accordance with the current International Code of Nomenclature for algae, fungi, and plants (McNeill et al. 2012), abbreviated as ICN. Herbarium abbreviations follow Thiers (2013). Taxonomic remarks are based on synonymies, discussions, and revisions published in European *Lactarius* monographs (Korhonen 1984, Heilmann-Clausen et al. 1998, Basso 1999, Kalamees 2011).

Results & discussions

Lactarius albocremeus Z. Schaef., Česká Mykologie 12: 211, 1958.

LATIN DIAGNOSIS/DESCRIPTION: Česká Mykologie 12: 211, 1958.

DETAILED CZECH DESCRIPTION: Česká Mykologie 12: 208–209, 1958.

HOLOTYPE — designated. Slovakia, Western Carpathians, NNE of Poprad, between the villages of Spišská Belá and Lendak, site called „Blomwiesen“, in fen meadow, close to *Betula* and *Salix* trees, alt. about 800 m, 11 Aug. 1957 leg. K. Kříž (BRNM; see Antonín & Vágner 1999).

ISOTYPE — a duplicate of the holotype collection (PRM 584029).

OTHER COLLECTIONS IDENTIFIED BY SCHAEFER — none. There are three later collected specimens identified (respectively) by J. Kubička, M. Svrček and Z. Pouzar, however, they represent neither original materials nor collections revised by Schaefer.

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — Basso (1999: 385, 389–390) regarded *L. albocremeus* as identical with *L. scoticus* Berk. & Broome. However, the Czech *Lactarius* specialist Pouzar feels that the current concept of *L. scoticus* differs from Berkeley & Broome's original concept (Z. Pouzar, pers. comm., May 2013). This discrepancy should be clarified and the name *L. albocremeus* considered as a possible name for *L. scoticus* auct. non Berk. & Broome.

Lactarius chrysophyllus Z. Schaef., Česká Mykologie 11: 52, 1957.

LATIN DIAGNOSIS/DESCRIPTION: Česká Mykologie 11: 52–53, 1957.

DETAILED CZECH DESCRIPTION: Česká Mykologie 11: 50–52, 1957.

HOLOTYPE — not designated.

OTHER TYPE COLLECTIONS — the protologue mentions six localities from the Czech Republic (Těchlovice, Čebínka, Roviny u Heroltic, Radíkovice, Kuřim, Sázava nad Sázavou), indicating potential syntypes, but there are no corresponding vouchers in PRM.

OTHER COLLECTIONS IDENTIFIED BY SCHAEFER — CZECH REPUBLIC, BOHEMIA, Rokycany, 22 Aug. 1942, collector unknown (PRM 195218). The collection was revised by Basso (1999: 144).

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — Basso (1999: 138, 143–144) considered *L. chrysophyllus* a synonym of *L. hyssiginus* (Fr.) Fr.

Lactarius cupricolor Z. Schaef., Česká Mykologie 20: 158, 1966.

LATIN DIAGNOSIS/DESCRIPTION: Česká Mykologie 20: 158, 1966.

DETAILED CZECH DESCRIPTION: Česká Mykologie 20: 154–156, 1966.

DETAILED GERMAN DESCRIPTION: Česká Mykologie 20: 156–157, 1966.

HOLOTYPE — designated. Czech Republic, Turnov district, Sychrov: castle park, under *Quercus*, *Picea*, *Abies* and distant *Fagus*, 27 Aug. 1961 leg. Z. Schaefer (PRM 584026).

PARATYPES — CZECH REPUBLIC, CENTRAL BOHEMIA, Olešovice: Struhařov, 15 Aug. 1957 leg. K. Kult (PRM 193972); Praha, Divoká Šárka, *Quercus* forest, 7 Sep. 1937 leg. J. Herink (PRM 193865). (Five other records mentioned in the protologue are potential paratypes, but there are no corresponding vouchers in PRM.)

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — species of unclear identity. For type study and discussion see Basso (1999: 131–132), who placed it under *L. vietus* but also compared it with *L. pallidus*.

Lactarius eburneus Z. Schaeff., Česká Mykologie 33: 4, 1979, nom. illegit., non Thiers 1957.

LATIN DESCRIPTION: Česká Mykologie 33: 4, 1979.

GERMAN DISCUSSION: Česká Mykologie 33: 4–5, 1979.

HOLOTYPE — designated. Czech Republic, central Bohemia, near Golčův Jeníkov, mixed forest, 22 Jul. 1949 leg. Z. Schaefer (herb. Z. Schaefer no. 112). Location unknown but probably discarded by Schaefer's family.

NOMENCLATURAL STATUS — valid, illegitimate (a later homonym of *L. eburneus* Thiers).

TAXONOMIC REMARKS — Basso (1999: 723, 735) considered *L. eburneus* Z. Schaeff. identical with *L. glaucescens* Crossl. (= *Lactifluus glaucescens* (Crossl.) Verbeke).

“*Lactarius echinosporus*” Z. Schaeff., Česká Mykologie 14: 237, 1960, nom. inval.

LATIN DIAGNOSIS/DESCRIPTION: Česká Mykologie 14: 237, 1960.

DETAILED CZECH DESCRIPTION: Česká Mykologie 14: 233–235, 1960.

HOLOTYPE — not designated.

SYNTYPES — Czech Republic, Central Bohemia, SW of Prague: Barrandian region, also called Český kras Karst, e.g. near Karlštejn castle, on calcareous bedrock, 1949 leg. K. Kult; 9 Sep. 1958 leg. Z. Schaefer (vouchers nonexistent).

OTHER COLLECTION IDENTIFIED BY SCHAEFER (not mentioned in the protologue) — CZECH REPUBLIC, CENTRAL BOHEMIA, between Karlštejn castle and the village of Mořina, 27 Aug. 1951 leg. A. Pilát (PRM 561154).

NOMENCLATURAL STATUS — invalid: no holotype designated.

TAXONOMIC REMARKS — a fungus belonging to *Russula delica* group (Basso 1999: 330, 454–455).

Lactarius hortensis Velen., České houby [Czech fungi], part 1: 163, 1920, var. *hortensis*

ORIGINAL CZECH DESCRIPTION: České houby [Czech fungi], part 1: 163–164, 1920.

LATIN DESCRIPTION BY SCHAEFER: Česká Mykologie 26: 143, 1972.

HOLOTYPE — nonexistent (Holec & Suková 2007). Czech Republic, central Bohemia, SE of Prague, Mnichovice, Velenovský's garden, under *Corylus* (Velenovský 1920: 163).

NEOTYPE — Slovakia, Banská Bystrica district, Harmanec, stand of *Corylus avellana*, 23 Aug. 1966 leg. Z. Schaefer (PRM 621095, designated by Schaefer 1972: 143).

NOMENCLATURAL STATUS — valid, legitimate. The neotype designation seems inappropriate as it originates from a different country than the original, particularly as the species is common in the holotype area.

TAXONOMIC REMARKS — Korhonen (1984: 130) regards *L. hortensis* as a good species, while Heilmann-Clausen et al. (1998: 52), Basso (1999: 117), Kalamees (2011: 122) regard it as identical with *L. pyrogalus* (Bull.) Fr.

Lactarius hradecensis Z. Schaefer, Česká Mykologie 2: 85, 1948.

LATIN DIAGNOSIS/DESCRIPTION: Česká Mykologie 2: 85, 1948.

DETAILED CZECH DESCRIPTION: Česká Mykologie 2: 83–85, 1948.

HOLOTYPE — nonexistent. Czech Republic, eastern Bohemia, near Hradec Králové, forest called Dehetník, under *Picea* and admixed *Pinus*, *Betula*, *Quercus*, 26 Aug. 1945 leg. Z. Schaefer (Schaefer 1948: 85).

NEOTYPE — Czech Republic, eastern Bohemia, near Hradec Králové, forest called Dehetník, under *Picea*, *Quercus*, *Betula*, 22 Aug. 1961 leg. Z. Schaefer (PRM 584032; designated by Schaefer 1966: 152, 157, as “typus”).

OTHER COLLECTIONS MENTIONED IN NEOTYPE PUBLICATION (Schaefer 1966) — CZECH REPUBLIC, BOHEMIA, Turnov, Sychrov: castle park, 24 Aug. 1961 leg. Z. Schaefer (PRM 584025); Turnov, Valdštýn (= Valdštejn), 19 Aug. 1945 leg. J. Herink (PRM 193660).

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — species of uncertain identity. Basso discussed it under *L. quietus* (Fr.) Fr. (Basso 1999: 504–506) and mentioned it briefly under *L. subdulcis* (Pers.) Gray (Basso 1999: 516).

Lactarius moravicus Z. Schaefer, Česká Mykologie 33: 10, 1979.

LATIN DESCRIPTION + GERMAN DISCUSSION: Česká Mykologie 33: 10, 1979.

HOLOTYPE — designated. Czech Republic, southwestern Moravia, Telč, near fish-pond Pařezitý rybník, *Picea* forest, 4 Aug. 1958 leg. Z. Schaefer (herb. Z. Schaefer no. 58: 21).

Location unknown but probably discarded by Schaefer's family.

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — species of unclear identity. Mentioned under *L. vellereus* var. *hometii* (Gillet) Boud. by Basso (1999: 722).

Lactarius pearsonii Z. Schaefer, Česká Mykologie 22: 19, 1968.

= *Lactarius mairei* var. *zonatus* A. Pearson, Naturalist, London: 100, 1950.

LATIN DESCRIPTION: Česká Mykologie 22: 19, 1968.

CZECH DISCUSSION: Česká Mykologie 22: 17, 1968. Detailed Czech description cited by Schaefer (1968: 17) was published by Pouzar (1954: 40–41, as “*L. aurantiacoochraceus*”).

HOLOTYPE — designated. Czech Republic, central Bohemia, Beroun district, Karlštejn nature reserve, valley of the Bubovický potok stream, site above its waterfalls, under *Fraxinus*, *Acer*, *Salix*, 23 Aug. 1953 leg. Z. Pouzar, F. Kotlaba & F. Hřebík (PRM 193531).

OTHER TYPE COLLECTIONS — Schaefer (1968: 17) wrote that the species is not rare in former Czechoslovakia. Although he listed localities in central Bohemia (vouchers in PRM), southern Moravia (vouchers in BRNM), and southern Slovakia (voucher in PRM), he did not cite any collections as paratypes. The existing vouchers represent original materials on which the protologue is based.

OTHER ORIGINAL MATERIALS IN PRM (identified as *L. mairei* var. *zonatus* by their collectors) — CZECH REPUBLIC, BOHEMIA, Praha: Kinského sady park, 9 Aug. 1968 leg. E. Wichanský (PRM 682631); 31 Aug. 1964 leg. V. Brambora (PRM 602362). — SLOVAKIA, SOUTHEASTERN SLOVAKIA, Slovenský kras Karst, the village of Vidová near Plešivec, 1 Jul. 1963 leg. F. Kotlaba et Z. Pouzar (PRM 583432).

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — Schaefer (1968: 17) rejected the synonymy of *L. mairei* var. *zonatus* with *L. aurantiacoochraceus* Lj.N. Vassiljeva, which had been proposed by Pouzar (1954). Heilmann-Clausen et al. (1998: 164), Basso (1999: 374, 378–379), and Kalamees (2011: 106) regard *L. pearsonii* as identical with *L. mairei* Malençon.

Lactarius pilatii Z. Schaefer, Česká Mykologie 22: 18, 1968.

LATIN DESCRIPTION: Česká Mykologie 22: 18–19, 1968.

DETAILED CZECH DESCRIPTION: Česká Mykologie 22: 17–18, 1968.

HOLOTYPE — designated. Czech Republic, southwestern Bohemia, Šumava Mts., near the village of Horská Kvilda, Zhůřská slať bog, alt. about 1100 m, under *Betula pubescens*, 22 Aug. 1966 leg. A. Pilát (PRM 624664).

PARATYPES — Czech Republic, southwestern Bohemia, Šumava Mts., near the village of Horská Kvilda, Zhůřská slať bog, alt. about 1100 m, under *Betula pubescens*, 16 Aug. 1965 leg. A. Pilát (PRM 624669, 624658); 16 Aug. 1967 leg. A. Pilát (PRM 628888); 18 Aug. 1967 leg. A. Pilát (PRM 628889); 26 Aug. 1967 leg. A. Pilát (PRM 628886, 628885).

OTHER COLLECTION BY A. PILÁT FROM THE TYPE LOCALITY (not mentioned by Schaefer 1968 but most probably studied by him) — 19 Aug. 1967 (PRM 628887).

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — good species (Heilmann-Clausen et al. 1998: 62–63, Basso 1999: 111–117, Kalamees 2011: 174). Kalamees (2011: 174) considers *L. moseri* Harmaja synonymous with *L. pilatii*. Kalamees cites photographs by Korhonen (1984: 134, labelled *L. moseri*).

Lactarius pinicola Smotl. ex Z. Schaefer, Schweizerische Zeitschrift für Pilzkunde 48: 141, 1970.

“*Lactarius deliciosus* var. *pinicola*” Smotlacha, Atlas hub jedlých a nejedlých [Atlas of edible and inedible fungi]: 219, 1947, nom. inval. [no Latin description].

LATIN DIAGNOSIS: Schaefer (1970: 141–142).

GERMAN DISCUSSION: Schaefer (1970: 139–142).

HOLOTYPE — designated. Czech Republic, northern Bohemia, district Jablonec nad Nisou, near Turnov, Frýdštejn: near the village of Sněhov, mixed forest (*Pinus*, *Picea*), under *Pinus*, 18 Oct. 1962 leg. Z. Schaefer (PRM 584024, originally labelled as *L. salmonicolor*).

OTHER COLLECTION IDENTIFIED BY SCHAEFER — CZECH REPUBLIC, BOHEMIA, Turnov, Třtí near Radimovice, 21 Sep. 1966 leg. Z. Schaefer (PRM 709711).

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — identical with *L. deliciosus* (L.) Gray (Heilmann-Clausen et al. 1998: 140; Basso 1999: 253, 259; Nuytinck & Verbeken 2005: 131; Kalamees 2011: 70).

Lactarius pyrogalus var. *umbrosus* Z. Schaefer, Česká Mykologie 26: 145, 1972.

CZECH AND LATIN DIAGNOSES: Česká Mykologie 26: 145, 1972.

HOLOTYPE — designated. Czech Republic, Bohemia, NE of Pardubice, near the village of Bělečko, *Picea* forest, 15 Aug. 1944 leg. Z. Schaefer (herb. Z. Schaefer). Location unknown but probably discarded by Schaefer's family.

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — taxonomic value of this variety is unclear. Discussed under *L. pyrogalus* by Basso (1999: 124).

“*Lactarius russuloides*” Z. Schaefer, Česká Mykologie 12: 205, 1958, nom. inval.

LATIN DIAGNOSIS/DESCRIPTION: none.

DETAILED CZECH DESCRIPTION: Česká Mykologie 12: 205–206, 1958.

HOLOTYPE — not designated. The description is based on 3 records from the Czech Republic (Telč, Hulišťata; Třeboň, Spolí; Třeboň, Domanín). None of these specimens is held in PRM.

OTHER COLLECTIONS IDENTIFIED OR REVISED BY SCHAEFER — CZECH REPUBLIC, BOHEMIA, Trhové Sviny, 17 Sep. 1964 leg. J. Kubička (PRM 603730); Tábor, Sudoměřice: Nemyšl, 9 Sep. 1949 leg. M. Svrček (PRM 615083); Poříčany: forest Kersko, 11 Oct. 1955 leg. Z. Pouzar (PRM 621218); Třeboň, Kozákovice, 15 Oct. 1967 leg. J. Kubička et Z. Pouzar (PRM 709721); Třeboň, Domanín, 23 Sep. 1964 leg. J. Kubička (PRM 603726); 7 Sep. 1964 (PRM 603728).

NOMENCLATURAL STATUS — invalid: lacking Latin description or diagnosis and holotype designation. Schaefer erroneously treated the name as a nomen novum (= replacement name; ICN Art. 6.11) for “*L. musteus*” sensu Favre (in Konrad & Maublanc 1937: tab. 331), Kühner & Romagnesi (1953: 477), and Neuhoﬀ (1956: 130) and “*L. pubescens*” sensu Bresadola (1929: tab. 360). Because none of these is a valid name, *L. russuloides* must be interpreted as a sp. nov., rather than a nom. nov.

TAXONOMIC REMARKS — Basso (1999: 171, 175) considers *L. russuloides* is identical with *L. musteus* Fr.

Lactarius syringinus Z. Schaefer., Česká Mykologie 10: 171, 1956.

LATIN DIAGNOSIS/DESCRIPTION: Česká Mykologie 10: 171–172, 1956.

DETAILED CZECH DESCRIPTION: Česká Mykologie 10: 168–171, 1956.

HOLOTYPE — designated. Czech Republic, central Bohemia, E of Praha, near Radošovice („Radešovice“) close to Říčany, site called Vojkov (name of a gamekeeper's lodge and a settlement E of the town of Říčany), in deciduous forest with admixed *Picea* and *Pinus*, Aug. 1953 leg. I. Charvát. Location unknown and possibly nonexistent; probably not preserved by Schaefer who obtained the material by surface mail from I. Charvát (Schaefer 1956: 169).

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — Heilmann-Clausen et al. (1998: 60–61) regard *L. syringinus* as a good species. Basso (1999: 130–131) discusses it under *L. vietus* (Fr.) Fr. and Kalamees (2011: 158) synonymized it with *L. vietus*. Based on more collections and sequences, both from Europe and Russia, *L. syringinus* really seems to fall within the variation of *L. vietus* (Verbeke, pers. comm. 2013).

Lactarius vellereus* var. *bertillonii Neuhoff ex Z. Schaefer., Česká Mykologie 33: 9, 1979.

≡ *Lactarius bertillonii* (Neuhoff ex Z. Schaefer.) Bon, Doc.
Mycol. 10(37–38): 92, 1980 [“1979”].

≡ *Lactifluus bertillonii* (Neuhoff ex Z. Schaefer.) Verbeke,
Mycotaxon 118: 451, 2012 [“2011”].

“*Lactarius vellereus* var. *bertillonii*” Neuhoff, Die Milchlinge:
93, 1956, nom. inval. [no Latin description].

LATIN DIAGNOSIS BY SCHAEFER: Česká Mykologie 33: 9, 1979.

GERMAN DISCUSSION BY SCHAEFER: Česká Mykologie 33: 8–9, 11, 1979.

HOLOTYPE — designated. Czech Republic, central Bohemia, Golčův Jeníkov, mixed forest: *Picea*, *Pinus*, *Abies*, *Betula*, *Quercus*, 22 Jul. 1949 leg. Z. Schaefer (herb. Z. Schaefer no. 41). Currently nonexistent, probably thrown away by Schaefer's family.

NOMENCLATURAL STATUS — valid, legitimate.

TAXONOMIC REMARKS — this variety is now generally accepted as a good species, *L. bertillonii* (≡ *Lactifluus bertillonii*) (Korhonen 1984; Heilmann-Clausen et al. 1998: 254–255; Basso 1999: 709, 713, 718; Kalamees 2011: 58).

Conclusions

We have shown that nine *Lactarius* taxa described by Schaefer are documented by vouchers in PRM. Although some holotypes are missing or nonexistent, paratypes, other original materials, or later collections identified by Schaefer are available for most of them. The taxa should be carefully studied

by classical and molecular methods to determine whether they represent good species (e.g. *L. albocremeus*) or placed into synonymy with earlier published taxa (their current revisions are insufficient). Currently accepted taxa are *L. pilatii* and *L. bertillonii* ($\equiv$ *Lactifluus bertillonii*). The accumulated data on available vouchers provide a good basis for both revisions and future typifications by experienced *Lactarius* specialists.

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***Phytophthora virginiana* sp. nov., a high-temperature tolerant species from irrigation water in Virginia**

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ABSTRACT — Isolates belonging to a previously unknown species of *Phytophthora* were recovered from irrigation reservoirs at several ornamental plant nurseries in Virginia. Morphological features of this species include abundant lateral chlamydospores in clarified V8 juice agar and carrot agar and terminal, ovoid to obpyriform, nonpapillate and noncaducous sporangia in soil water extract. All tested isolates are silent A¹ mating type. They did not produce any sexual structures but induced A² mating type testers of *P. cinnamomi* and *P. cryptogea* to produce gametangia. Sequence analysis of the internal transcribed spacer (ITS) region confirmed that this species belongs to the high-temperature tolerant cluster within *Phytophthora* clade 9. Its ITS sequence differs from those of its two closest relatives, *P. hydropathica* and *P. parsiana*, by >26 bp. Based on these morphological, physiological, and molecular characteristics, we recognise it as a new species, described here as *Phytophthora virginiana*.

KEY WORDS — aquatic habitat, oomycetes, phylogeny, self-sterile, taxonomy

Introduction

The genus *Phytophthora* de Bary contains a number of destructive plant pathogens (Erwin & Ribeiro 1996). They are responsible for many historical and current epidemics of plant diseases including late blight of potatoes caused by *P. infestans*, ink disease of chestnut trees caused by *P. cambivora*, and sudden oak death caused by *P. ramorum* (Erwin & Ribeiro 1996, Goheen et al. 2002, Rizzo et al. 2002). One reason that *Phytophthora* species are widely spread plant pathogens is that they are well adapted to aquatic environments and dispersed by water (Blackwell 1944, Hong & Moorman 2005). If water is directly used for irrigation in crop production areas without proper decontamination, *Phytophthora* pathogens in the water can spread rapidly from field to field through irrigation systems, severely damaging ornamental and other crops.

Previous studies have revealed the presence of at least 20 *Phytophthora* species in aquatic environments (Hong & Moorman 2005), including many notorious plant pathogens such as *P. capsici* (Roberts et al. 2005), *P. nicotianae* (Thomson & Allen 1976), and *P. ramorum* (Werres et al. 2007). Other *Phytophthora* species regarded as opportunistic plant pathogens or lacking recorded pathogenicity also survive in the irrigation systems, such as *P. irrigata* (Hong et al. 2008), *P. hydrogena* (Yang et al. 2014), and *P. gonapodyides* (Pittis & Colhoun 1984). Many new *Phytophthora* taxa also exist in irrigation water and other aquatic environments. In Virginia alone, approximately 15 known *Phytophthora* species and hundreds of isolates representing unknown taxa have been recovered from irrigation water at ornamental plant nurseries (Hong et al. 2008). It still is not known whether these novel *Phytophthora* species pose a threat to nursery production (Hong et al. 2008, Yang et al. 2014). These species may also be confused with major plant pathogenic species. Hence, describing these new species is important for reducing the risk of misidentifying high-impact *Phytophthora* species and minimizing the threat that *Phytophthora* species pose to crops and natural plants (Gallegly & Hong 2008).

In this study we formally name a novel species, *Phytophthora virginiana*. Isolates were recovered during statewide surveys in Virginia, USA. We provide detailed morphological, physiological, and phylogenetic evidence to separate *P. virginiana* from all known *Phytophthora* species.

Materials & methods

Cultures

Isolates of *Phytophthora virginiana* were recovered from runoff containment basins and irrigation reservoirs at ornamental plant nurseries in several Virginia counties. The five representative isolates examined in this study were obtained during 2006–7 by baiting with rhododendron or camellia leaves (Bush et al. 2003). Agar blocks with actively growing cultures in 20% clarified V8 juice agar (CV8A) were transferred into microtubes with sterile distilled water for long-term storage at both 15 and –80°C. Sequences from all isolates were analyzed. Isolates 44G6 and 46A2 were also morphologically examined and tested for cardinal temperatures.

Sequencing and phylogeny

DNA extraction followed Hong et al. (2008). PCR amplifications of the internal transcribed spacer (ITS) region covering ITS1, 5.8S rRNA gene, and ITS2 were performed using primer pair ITS6F4R (Cooke et al. 2000). The reaction mix recipe and PCR program were applied according to Kong et al. (2003). Sequencing was done at the University of Kentucky Advanced Genetic Technologies Center (Lexington, KY). Sequences of both directions were visualized with Finch TV v. 1.4.0., aligned using Clustal W in MEGA5 (Tamura et al. 2011), and edited manually to correct obvious errors. Sequences of *P. virginiana* isolates were aligned with those of other clade 9 species and representative *Phytophthora* species from other clades using Clustal W in

MEGA5 (Tamura et al. 2011). *Pythium aphanidermatum* was used as an outgroup. The phylogeny was reconstructed in MEGA5 using the Maximum Likelihood method based on the Tamura-Nei model (Tamura & Nei 1993) with 1000 bootstrap replicates.

Cardinal temperatures

Isolates 44G6 and 46A2 were subcultured on CV8A and carrot agar (CA) and incubated at 5, 10, 15, 20, 25, 30, 35, and 40°C. Agar blocks (5 mm diam.) were taken from 7-day-old cultures using a flamed cork borer and placed upside down at the center of Petri dishes. For each isolate, triplicate dishes per medium were placed in an incubator at a designated temperature. Two colony growth measurements per colony were taken after 4 days when the fastest growing colony was c. 1 cm from the dish edge. This test for cardinal temperatures was repeated. Means (with standard errors) of daily radial growth were plotted against temperature using the gplots package v. 2.11.0 (Warnes et al. 2012) in R statistical software v. 2.15.0 (R Core Team 2012). Analysis of variance was conducted in R to determine whether the measurements were statistically different between two isolates and experiments.

Morphology

Colony morphology of *P. virginiana* was noted and photographed from 10-day-old cultures on CV8A, CA, malt extract agar (MEA), and potato dextrose agar (PDA) at 20°C in the dark.

Sporangia were produced by incubating agar blocks with actively growing cultures ($\leq$ 2 weeks) in non-sterile 1.5% soil water extract solution (SWE, 15 g of non-*Phytophthora* containing nature soil/1 L distilled water) for 7–8 hours under cool-white fluorescent lamps at room temperature (c. 23°C). Mature chlamydospores were observed directly on 20-day-old cultures. Sporangia and chlamydospores were photographed using a Nikon Fujix Digital Camera HC-300Zi connected to a Nikon Labophot-2 microscope at 1000 $\times$. Both length and width of 50 randomly selected mature sporangia of *P. virginiana* and two perpendicular diameters of 30 chlamydospores were measured using Image-Pro[®] Plus v. 5.1.2.53.

Mating type of *P. virginiana* isolates was determined by placing each isolate with an A¹ or A² mating type tester of *P. cinnamomi* in dual cultures on hemp seed agar (HSA). The polycarbonate membrane method (Ko 1978, Gallegly & Hong 2008) was used to induce selfed gametangia of *P. virginiana* in the presence of its opposite mating type tester at room temperature. Several heterothallic species including *P. cinnamomi*, *P. cambivora*, *P. meadii*, *P. nicotianae*, and *P. cryptogea* were used as mating type testers. When no sexual organ was found after being paired for up to three months at room temperature in dark, additional polycarbonate membrane tests were conducted at 20 and 25°C.

Results

Sequencing and phylogeny

All *P. virginiana* isolates produced identical ITS sequences of 745 bp (ITS1 = 180 bp, 5.8s gene = 127 bp, ITS2 = 438 bp) that differed from those of all tested *Phytophthora* species. *Phytophthora virginiana* differed by 26 bp (11 bp in ITS1,

15 bp in ITS2) from its closest relative, the type isolate 5D1 of *P. hydropathica* (GenBank EU583793).

The ITS maximum likelihood phylogenetic trees (FIG. 1) placed *P. virginiana* in clade 9 of *Phytophthora* (Blair et al. 2008). *Phytophthora virginiana* isolates were supported as a taxon unique from all other known species by a strong bootstrap (FIG. 1). GenBank accession numbers generated in this study and used for phylogeny construction are included in FIG. 1.

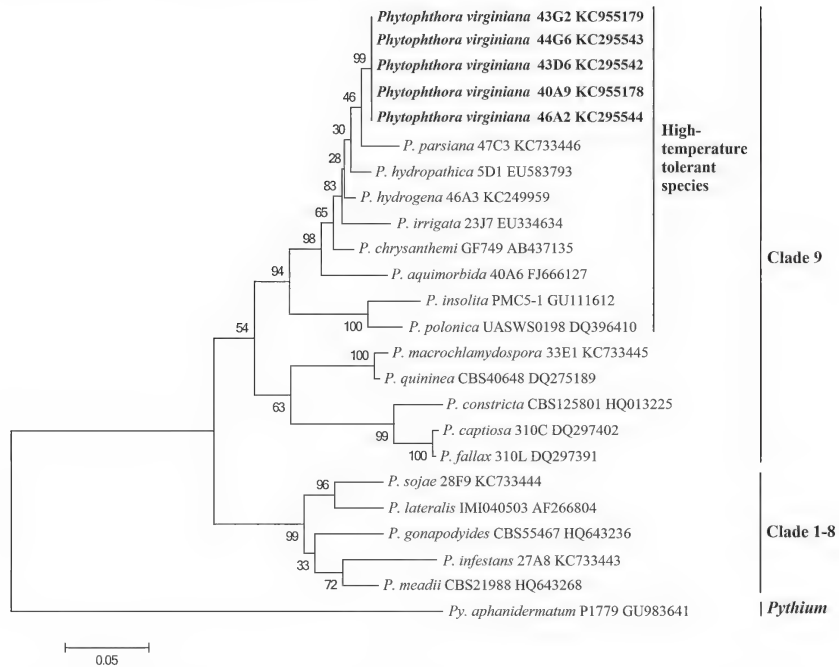


FIGURE 1. Maximum likelihood phylogenetic tree for species in *Phytophthora* clade 9 including *Phytophthora virginiana* and reference species in other clades based on ITS sequences. Alignment was conducted with Clustal W and the phylogenetic tree was generated in MEGA 5.

Cardinal temperatures

Measurements of radial growth were statistically identical between two *P. virginiana* isolates ($P = 0.21$) and two experiments ($P = 0.25$). Temperature-growth relation of *P. virginiana* isolates is shown in FIG. 2. Neither isolate grew on tested media at 5°C. The optimum temperature was 30°C on both CV8A and CA. Both isolates grew well at 35°C with 46A2 growing >5 mm daily on both media and 44G6 growing ~ 5 mm daily on CV8A. However, 44G6 grew relatively slowly on CA with an average growth rate of 1.6 mm.d⁻¹ in both experiments. No growth of 44G6 was observed on CA at 40°C, whereas 46A2 had notable growth on both media, as did 44G6 on CV8A at 40°C.

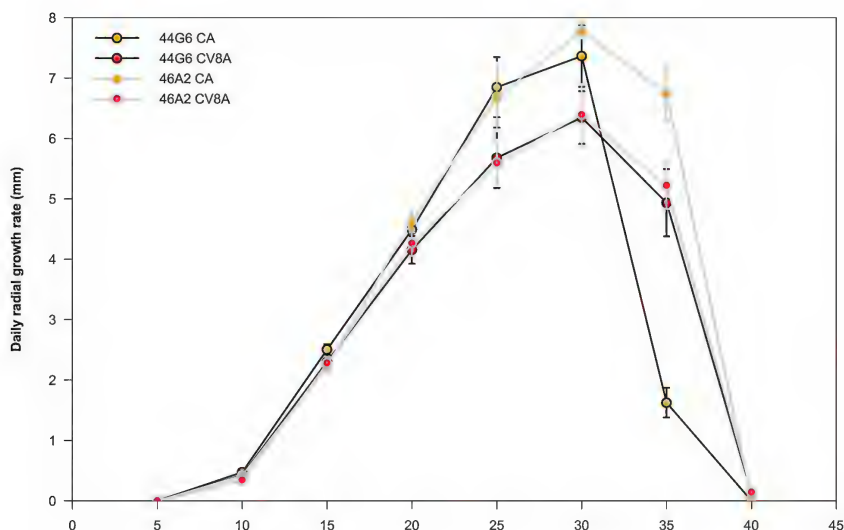


FIGURE 2. *Phytophthora virginiana*. Average daily radial growth of on carrot agar (CA) and clarified V8 juice agar (CV8A).

Colony morphology

After growing in the dark at 20°C for 10 days, the colonies of the two *P. virginiana* isolates were photographed (FIG. 3). The growth patterns of both isolates were similar on each tested medium. On CA, they grew fast and formed radiate colonies with relatively smooth edges, producing abundant aerial mycelia at the center and scattered at the colony intermediate and edge. On CV8A, they formed similar chrysanthemum colony patterns with cotton-like aerial mycelia at the colony center. On MEA, both formed tufted to chrysanthemum colonies with discontinuous edges. Colonies on PDA had dense aerial mycelia and expanded less than on CV8A.

Taxonomy

Phytophthora virginiana Xiao Yang & C.X. Hong, sp. nov.

FIG. 4

MYCOBANK MB 804533

Differs from *Phytophthora hydropathica* by abundant, thin-walled, lateral chlamydospores.

TYPE: USA, Virginia, baited with camellia leaves from irrigation water of an irrigation runoff reservoir in a production perennial nursery, October 2007, collected by Chuanxue Hong. **Holotype**, ATCC MYA-4927; ex-type culture, 46A2 (GenBank KC295544).

ETYMOLOGY: '*virginiana*' refers to the Commonwealth of Virginia, where the new species was initially recovered.

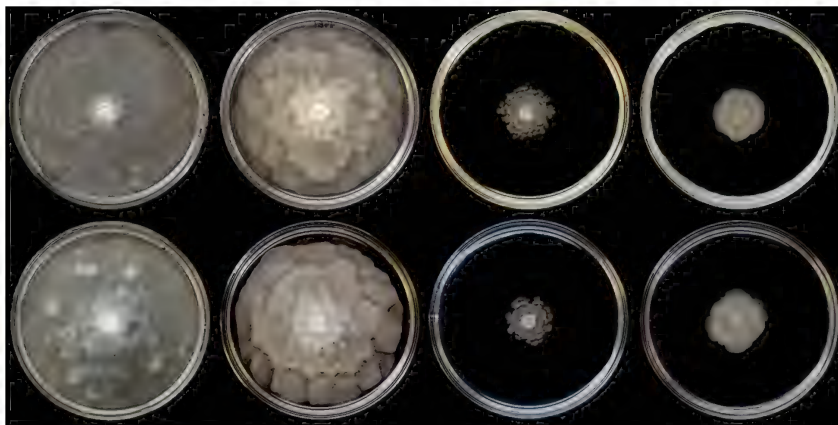


FIGURE 3. Colony morphology of *Phytophthora virginiana* isolates 44G6 (top) and 46A2 (bottom) after 10-days growth at 20°C on (left to right) carrot agar, clarified V8 juice agar, malt extract agar and potato dextrose agar.

SPORANGIA produced occasionally by aged cultures grown on carrot agar and 20% clarified V8 juice agar, and abundantly by culture plugs submerged in 1.5% soil water extract under light within 10 hours. Sporangial shape mostly ovoid to obpyriform and sometimes limoniform to ellipsoid with distorted-shaped sporangia such as peapod-shaped and peanut-shaped on culture plugs submerged in SWE after 20 hours. Sporangia terminal, nonpapillate and noncaducous; av. $51.7 \times 32.5 \mu\text{m}$. Internal proliferation of sporangiophore common, nested or extended. SPORANGIOPHORE erect, unbranched with occasional swelling. HYPHAL SWELLINGS common, often peanut-shaped, angular, or variously distorted in shapes. CHLAMYDOSPORES abundant, thin-walled, spherical and lateral produced by mature cultures av. $43.5 \mu\text{m}$ diam, sometimes on short stalks, with tapered base or clustered. Terminal chlamydospores rare.

Phytophthora virginiana is self-sterile, producing no sexual organ in single cultures. In the polycarbonate membrane tests, *P. virginiana* isolates belong to silent A¹ mating type, producing no sexual organ after up to 90-day-pairing, but stimulating A² mating type isolates of *P. cinnamomi* and *P. cryptogea* to produce gametangia after 30-day-pairing at 20, 25°C and room temperature (c. 23°C).

ADDITIONAL ISOLATES EXAMINED: USA, VIRGINIA, baited with rhododendron or camellia leaves from irrigation runoff reservoirs in several perennial nurseries: June 2006, 40A9 (GenBank KC955178); November 2006, 43D6 (GenBank KC295542); May 2007, 43G2 (GenBank KC955179); May 2007, 44G6 (GenBank KC295543).

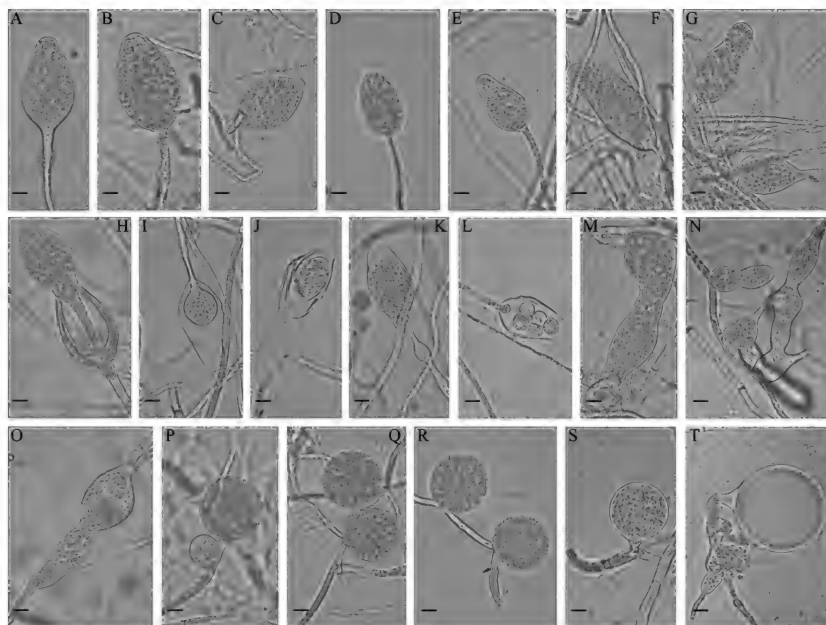


FIGURE 4. *Phytophthora virginiana*. Morphology of asexual structures. A–G: Sporangia in various shapes; A: Ovoid sporangium; B: Ovoid sporangium appearing semi-papillate just before releasing zoospores; C: Limoniform sporangium; D: Ellipsoid sporangium; E: Obpyriform sporangium; F: Distorted, peapod-shaped sporangium; G: Distorted, peanut-shaped sporangia. H: Extended proliferation. I–K: Nested proliferation with intercalary swelling on sporangiophore in K. L: Sporangium releasing zoospores with an incipient proliferation. M–N: Distorted hyphal swellings. O: Intercalary swelling. P: Lateral chlamydospore and hyphal swelling. Q–S: Lateral chlamydospores; S: Lateral chlamydospore with a tapered base on a short stalk. T: Terminal, aborted chlamydospore. Bars = 10 μ m.

Discussion

Phytophthora virginiana was recovered from nursery irrigation water. This new species has unique morphological and physiological attributes as well as molecular signature, so that it can be readily distinguished from all known *Phytophthora* species. It is the only species that is heterothallic, grows well at 35°C, and produces abundant lateral chlamydospores. *Phytophthora insolita* (Ann & Ko 1980), which also grows well at 35°C and produces abundant thin-walled chlamydospores, is homothallic and produces terminal chlamydospores. *Phytophthora lateralis* (Tucker & Milbrath 1942) and *P. quininea* (Crandall 1947) also produce abundant lateral chlamydospores but are homothallic and did not sustain growth at 35°C (Tucker & Milbrath 1942, Crandall 1947). *Phytophthora quininea* also produces intercalary chlamydospores (Crandall 1947) whereas

P. virginiana does not. Among the known heterothallic, high-temperature tolerant species that grow well at 35°C, only *P. virginiana* produces abundant lateral chlamydospores. *Phytophthora melonis*, *P. hydrogena*, and *P. irrigata* do not produce chlamydospores in fresh agar media (Ho et al. 2007, Hong et al. 2008, Yang et al. 2014). Some isolates of *P. drechsleri* were reported to produce much smaller chlamydospores (diam. 7.9 µm) (Erwin & Ribeiro 1996) than those of *P. virginiana* (diam. 43.5 µm). *Phytophthora hydropathica* and some *P. parsiana* isolates frequently produce chlamydospores in fresh cultures (Hong et al. 2010, Mostowfizadeh-Ghalamfarsa et al. 2008). However, these two species produce mostly terminal chlamydospores, which are rare in *P. virginiana*. The average chlamydospore sizes of *P. hydropathica* (diam. 37 µm) and *P. parsiana* (diam. 27–37.5 µm) are also smaller than that of *P. virginiana*. Additionally, the ITS sequence of *P. virginiana* differs from its two closely related species by 26 bp (*P. hydropathica*) and 39 bp (*P. parsiana*). This sequence difference is another important criterion for separating *P. virginiana* from all other existing *Phytophthora* species.

The phylogenetic placement of *P. virginiana* provides further evidence to the argument that there is a high-temperature tolerant cluster (FIG. 1) in clade 9 of the genus *Phytophthora* (Yang et al. 2014). *Phytophthora virginiana* and all other species within this unique cluster grow well at 35°C and some survive at 40°C (FIG. 2). To date, species belonging to this cluster have been found on several continents including Europe, North America, South America, and Asia. *Phytophthora polonica* was first described in Poland (Belbahri et al. 2006). Irrigation reservoirs in Virginia contain diverse species belonging to this cluster including *P. aquimorbida* (Hong et al. 2012), *P. hydropathica* (Hong et al. 2010), *P. hydrogena* (Yang et al. 2014), *P. irrigata* (Hong et al. 2008), and this new species *P. virginiana*. *Phytophthora chrysanthemi*, *P. insolita* and *P. parsiana* were first reported from Asia (Ann & Ko 1980, Mostowfizadeh-Ghalamfarsa et al. 2008, Naher et al. 2011). Also, a provisional species belonging to this cluster, *Phytophthora* sp. “*lagoariana*,” recovered from the Amazonian rainforest, also grows well at 35°C (data not shown). The unique correlation between physiological and phylogenetic characteristics indicates that these high-temperature tolerant species may originate from tropical or subtropical environments, and increasing international trade may have contributed to current global distribution of these species.

The ecological and economic impacts caused by *P. virginiana* are not clear at this time. All isolates were recovered from irrigation water at several ornamental plant nurseries in Virginia by baiting. However, plants diseased by *P. virginiana* have not been observed at the same nurseries. This does not necessarily mean that *P. virginiana* will not cause severe damage when introduced to

new environments. Investigations into its host range and ecological roles in irrigation systems are warranted.

Acknowledgments

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MYCOTAXON

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**New records of *Puccinia* on *Poaceae*
from Khyber Pakhtunkhwa, Pakistan**A. ISHAQ^{1*}, N.S. AFSHAN² & A.N. KHALID¹¹*Department of Botany & ²Centre for Undergraduate Studies, University of the Punjab,
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ABSTRACT — *Puccinia arthraxonis-ciliaris* and *P. pseudocesatii* were collected from Khyber Pakhtunkhwa and are new records for Pakistan.

KEY WORDS — Naran, *Pucciniales*, rust fungi

Introduction

Khyber Pakhtunkhwa (KPK), formerly known as the Northwest Frontier Province (NWFP), is one of the five provinces of Pakistan, located in the northwest of the country. It is situated at approximately 34.00°N 71.32°E (FIG. 1). Khyber Pakhtunkhwa is famous for hill coniferous forests, herbal plants, and large biodiversity. This floristically rich area is affected by many biotic and abiotic stresses including plant diseases such as leaf blights, red rot, smut, mosaic, and rust (Asad et al. 2007). One hundred seventy taxa of rust fungi have been reported from this area (Afshan & Khalid 2008, 2009; Afshan et al. 2007, 2008a,b,c,d, 2010; Khalid & Afshan 2009; Ahmad et al. 1997; Iqbal et al. 2008). The number of rust species recorded from this area is expected to increase in future due to extensive exploration.

We describe below three new rusts from Khyber Pakhtunkhwa that bring the total rust taxa recorded from the area to 173: *Puccinia pseudocesatii* on *Dichanthium annulatum* and *P. arthraxonis-ciliaris* on *Arthraxon* sp. (both new records for Pakistan) and *P. helictotrichi* var. *pakistanica* on *Helictotrichon junghuhnii*.

Materials & methods

During an exploration of the rust diversity in KPK, rust infected plants and their inflorescences were collected from different areas of the province and compared morphological with earlier herbarium collections. Freehand sections & scrape mounts

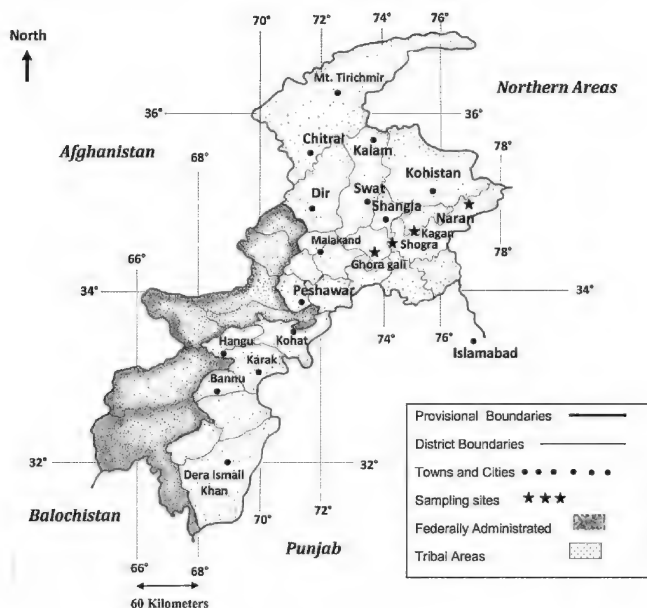


FIGURE 1: Map of Khyber-Pakhtunkhwa showing sampling sites.

of infected plant materials were made in lactic acid. The plants were photographed and infected portions were observed under stereomicroscope. Twenty spores of each spore state were examined under microscope (Nikon YS 100) and paraphyses and spore dimensions were taken by an Ocular micrometer (Zeiss Eyepiece Screw Micrometer). Sections, paraphyses and spores were microphotographed by digiporo-Labomed. Illustrations of spores and paraphyses were made under Lucida camera (Ernst Leitz Wetzlar Germany).

New records

Puccinia arthraxonis-ciliaris Cummins, Uredineana 4: 16 (1953)

FIG. 2

SPERMOGONIA, AECIA & UREDINIA not found. TELIA amphigenous, black, scattered. TELIOSPORES ellipsoid to oblong-ellipsoid, light brown, 1–2 celled, mostly 2–celled spores $19\text{--}21\text{--}28 \times 42\text{--}49\text{--}(57) \mu\text{m}$; apex $6\text{--}10 \mu\text{m}$ thick; wall $2\text{--}4 \mu\text{m}$ thick; pedicel hyaline, $5\text{--}9 \times (23\text{--})29\text{--}54 \mu\text{m}$. 1-celled spores $21\text{--}26\text{--}(31) \times (26\text{--})34\text{--}38 \mu\text{m}$; apex $7\text{--}10 \mu\text{m}$ thick; wall $2\text{--}3 \mu\text{m}$ thick; pedicel up to $44 \mu\text{m}$ long.

MATERIAL EXAMINED: PAKISTAN, KHYBER PAKHTUNKHWA, Ghora gali, 1691 m a. s. l., on *Arthraxon* sp., stage III, 30 April 2008. A. Ishaq AM69 (LAH 1166).

COMMENTS: *Puccinia arthraxonis-ciliaris* has previously been reported on *Arthraxon hispidus* (Thunb.) Makino from China, India, Japan, Mauritius,

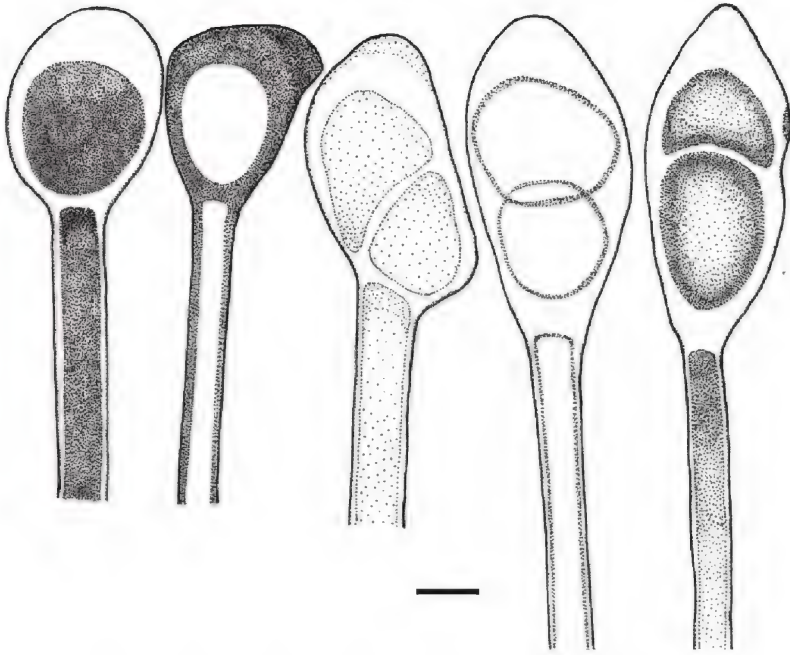


FIGURE 2: *Puccinia arthraxonis-ciliaris*. Teliospores. Scale bar = 14 μm .

New Guinea, and Philippines (Cummins 1971 and represents a new species record for Pakistan. *Puccinia arthraxonis* (Henn.) Syd. et al. has previously been reported from Pakistan on different *Arthraxon* species (Ahmad 1976; Khalid et al. 1993).

Puccinia pseudocesatii Cummins, Uredineana 4: 71 (1953)

FIG. 3

SPERMOGONIA, AECIA & UREDINIA not found. TELIA amphigenous, pulvinate, black. TELIOSPORES ellipsoid, hyaline to light brown, 2-celled, 3-celled rarely, $10\text{--}20 \times (35\text{--})44\text{--}60 \mu\text{m}$, sometimes upper cell is wider than lower one, $10\text{--}27 \mu\text{m}$ wide; apex $5\text{--}15(-18) \mu\text{m}$ thick; wall $1.5\text{--}2 \mu\text{m}$ thick; pedicel hyaline, fragile, $5\text{--}8 \times 23\text{--}67 \mu\text{m}$.

MATERIAL EXAMINED: PAKISTAN, KHYBER PAKHTUNKHWA, Ghora Gali, 2009 m a.s.l., on *Dichanthium annulatum* (Forssk.) Stapf, stage III, 29 March 2009, A. Ishaq AM31 (LAH 1172)

COMMENTS: *Puccinia pseudocesatii* has previously been reported on *Bothriochloa ischaemum* (L.) Keng and *Chrysopogon gryllus* (L.) Trin. from southern Europe

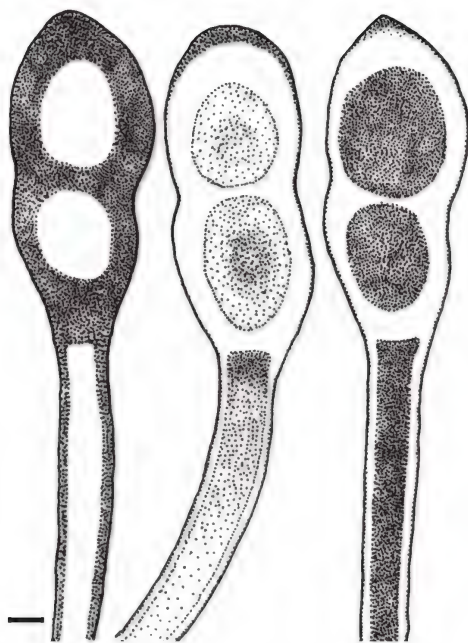


FIGURE 3: *Puccinia pseudocesatii*. Teliospores. Scale bar = 17 μ m.

(Cummins 1971). From Pakistan, *P. cesatii* J. Schröt., *P. duthiei* Ellis & Tracy, *P. dichanthii* Afshan & Khalid, *Uromyces andropogonis-annulati* Syd. et al. and *U. clignyi* Pat. & Har. have previously been reported on *Dichanthium annulatum* (Ahmad 1956a,b; Hasnain et al. 1959; Ghaffar and Kafi 1968; Afshan et al. 2010).

This is a new record for Pakistan and *Dichanthium annulatum* represents a new host for this rust fungus.

Puccinia helictotrichi* var. *pakistanica Afshan & Khalid, Mycotaxon 112: 487 (2010)

FIG. 4

SPERMOGONIA and AECIA unknown. UREDINIA scattered on whole leaf surface, naked, amphigenous, golden brown. UREDINIOSPORES globose to subglobose, hyaline, 15–24 $\times$ 20–26 μ m; wall 1.5–3 μ m thick, hyaline, echinulate; germ pore obscure. TELIA amphigenous, golden brown, loculate, 100–200 $\times$ 40–80 μ m. TELIOSPORES elongated to cylindrical, 14–24 $\times$ 36–49 μ m; apex 2–3.7 μ m thick; wall 1.5–3 μ m thick; pedicel hyaline, 3–7 $\times$ 3.3–13 μ m.

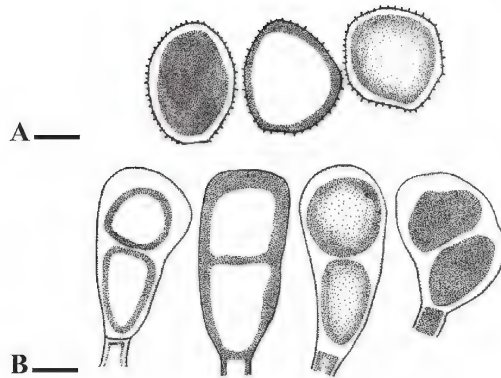


FIGURE 4: *Puccinia helictotrichi* var. *pakistanica*.

A. Urediniospores showing echinulate surface ornamentation. B. Teliospores.

Scale bars: A = 9 μ m; B = 10 μ m.

MATERIAL EXAMINED: PAKISTAN, KHYBER PAKHTUNKHWA, Shogran, 2362 m a.s.l., on *Helictotrichon junghuhnii* (Buse) Henrard (= *H. asperum* (Munro ex Thwaites) Bor), stages II & III, 28 August 2010, A. Ishaq AM04 (LAH 1145); Naran, 2427–3200 m a.s.l., on leaves of *Helictotrichon* sp., stages II & II, 29 August 2008, A. Ishaq AM15 (LAH 1149).

COMMENTS: *Puccinia helictotrichi* var. *pakistanica* has been previously reported on *Helictotrichon junghuhnii* (= *H. virescens* (Nees ex Steud.) Henrard) from Fairy Meadows, Northern Areas (Afshan et al. 2010). This represents a new record for Khyber Pakhtunkhwa.

Acknowledgements

We sincerely thank Dr. Abdul Rehman Niazi (Department of Botany, University of the Punjab, Lahore, Pakistan) and Dr. Omar Páino Perdomo (Dominican Society of Mycology, Santo Domingo, Dominican Republic) for their valuable suggestions to improve the manuscript and acting as presubmission reviewers.

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MYCOTAXON

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**The olive goblet: *Peziza oliviae*,
a new cup fungus growing underwater in Oregon**

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ABSTRACT — A new species, *Peziza oliviae*, is described from stream habitats in the Oregon Cascade Mountains (USA) based on morphology, habitat, and ITS and LSU nrDNA sequence data. This new member of the *Ascomycota* grows underwater on sticks and decomposing wood as well as near running water where the woody substrate is saturated.

KEY WORDS — *Pezizaceae*, underwater, monitoring, survey, manage

Introduction

Surveys for rare and endangered fungi in Oregon continue to be part of management practices, which now include stream habitats in search protocols for rare macrofungi that fruit underwater, such as *Vibrissea truncorum* (*Ascomycota*) and *Psathyrella aquatica* (*Basidiomycota*) (Frank et al. 2010; Oregon Biodiversity 2010). While only one gilled mushroom, *P. aquatica*, from the Rogue River in southern Oregon, is known to grow and fruit underwater, several ascomycetes fruit when submerged. *Cudoniella clavus* forms tan to gray fruiting bodies on submerged sticks, while *Vibrissea truncorum* and *Mitrula* spp. form orange caps on submerged sticks as well as on wet woody debris near water. Sessile macrofungi (e.g., *Vibrissea filisporia*, *Scutellinia scutellata*, *Pachyella clypeata*, *Adelphella babingtonii*) fruit underwater in streams in Oregon, and the new genus *Aquapeziza* (*Pezizaceae*) was recently described for a cup fungus fruiting underwater in China (Pfister 1973; Wang et al. 2005; Pfister et al. 2008; Hu et al. 2012). Aquatic microfungi are also classified in the *Oomycota*, *Chytridiomycota*, and aquatic hyphomycetes as well as new genera in the *Leotiomycetes* and *Sordariomycetes* from Florida and Costa Rica (Raja et al. 2009; Ferrer et al. 2012). Documentation of new and unusual fungal biodiversity provides target descriptions and DNA barcodes useful for monitoring and conservation (Halme et al. 2012).

In the broad sense, *Peziza* historically encompassed a variety of ascomal morphologies, including the archetypal sessile cup, stalked goblets, and convoluted truffle-like sequestrate fungi. Molecular data indicate that *Peziza* s.l. is polyphyletic and should be separated into several distinct genera, with the core group (*Peziza* s.s.) surrounding the generic type, *P. vesiculosa*. Fungi in the core group are saprotrophic and characterized by an amyloid ring at the tips of the asci, which form a palisade with thinner paraphyses along a more or less cup-shaped hymenium. They are represented by ellipsoid spores that may be smooth or ornamented; a stalk may be present but is usually not prominent, forming just a point of attachment to the substrate (Dennis 1968; Korf 1973; Breitenbach & Kränzlin 1984; Tylutki 1979; Hansen et al. 2001, 2002).

During surveys for rare species in central Oregon, I repeatedly collected an olive-brown stalked cup fungus growing underwater in small streams in the Willamette National Forest. Previously, no species of *Peziza* s.s. have been reported growing underwater in Oregon. Aquatic fruiting is such an unusual phenomenon that mycologists apply special scrutiny to confirm that a fungus has not originally fruited above water and subsequently fallen in or become submerged in rising waters. The fungus, which does not match any previously described species on survey lists or in scientific literature, is described here as *Peziza oliviae*.

Materials & methods

Streams, riverbanks, and saturated woody substrates were surveyed for macrofungi during May–November 2011 and May–August 2012 in the Willamette and Mount Hood National Forests. Site locations (UTM NAD83 Zone 10) were determined and recorded using a Garmin 450 portable GPS unit. Collections were mapped, described in the field. Photographs of fresh material were taken with a Canon T2i digital camera (field) or under a Leica MZ75 dissecting microscope (laboratory). Fresh hand sections mounted in distilled water and Melzer's reagent were viewed under a Leica DMLB compound microscope. Thirty spores from each of eight collections were measured at 1000×. All microscopic measurements were made from sections mounted in distilled water.

DNA was extracted, amplified, and sequenced following Frank et al. (2010): fresh fungal tissue was ground with micropestles in CTAB buffer, extracted with chloroform, and amplified with PCR primers ITS1f, ITS4, and TW13. Internal primers ITS1 and ITS4r were used for sequencing reactions. After sequences were edited with Chromas 1.45 (McCarthy 1998), contiguous sequences were assembled in Sequencher v4.7 (Gene Codes Corp. Ann Arbor, MI) and compared to other fungal ITS and LSU sequences in GenBank with BLAST (Altschul et al. 1990). MAFFT and ClustalX were used to generate multiple sequence alignments (Katoh et al. 2002; Thompson et al. 1997). Alignments were edited manually using BioEdit and Mesquite (Hall 1999; Maddison & Maddison 2011). Phylogenetic trees, using maximum likelihood with 1000 bootstrap replicates, were generated using fastDNAm1 (Felsenstein 1981; Olsen et al. 1994) through the Mobyle portal of the Pasteur Institute (<http://mobyle.pasteur.fr>). ML analyses using

settings that correspond to the HKY85 model, and parsimony analyses with 1000 bootstrap replicates and 1000 jack-knife replicates, were generated using PAUP* 4.10b10 (Swofford 2002). Consensus trees with 50% majority-rule were generated using the tree-bisection-reconnection branch-swapping algorithm. All characters were given equal weight; gaps were treated as missing.

Of the 41 aligned ITS sequences, five were generated from collections of *Peziza oliviae*, one was generated from *Peziza* sp. collected in southern Oregon, and 35 were obtained from GenBank. ITS and LSU rDNA sequences have been deposited in GenBank; ITS alignment and trees were submitted to TreeBase.org.

Results

Ten collections of *P. oliviae* were made during July–October 2011 and June–August 2012. Ascocarps were found growing from stream bottoms submerged 10–25 cm in running water or on saturated wood near running water in first order streams in the Santiam and Breitenbush watersheds at 900–1400 m elevations.

ITS nrDNA was amplified and sequenced for five collections of *P. oliviae* and for one morphologically similar *Peziza* sp. collected underwater in southern Oregon (JLF2167). LSU nrDNA was amplified and sequenced for three collections of *P. oliviae* and for *Peziza* sp. (JLF2167). Sequence data have been deposited in GenBank (JX415339–JX415342 and KC916727–KC916729).

Edited alignments of 41 ITS sequences generated consensus trees using parsimony with 774 total, 256 constant, 117 variable, and 401 parsimony-informative characters. Maximum Likelihood and Maximum Parsimony analyses support the molecular uniqueness of this new species, with *P. oliviae* nearest to the European *P. lohjaensis* (PLATE 1). Maximum Parsimony analysis and pairwise comparisons of LSU sequence data confirm the placement of *P. oliviae* in *Peziza* s.s. Alignments and trees are available at <http://purl.org/phylo/treebase/phyloids/study/TB2:S14001>.

Morphological and molecular analyses support the designation of this unusual stalked cup as a new species. This cup fungus grows underwater on sticks and wood embedded in the sediments, pebbles, and cobble of mountain stream bottoms and above water on saturated wood near cold mountain streams in the Oregon Cascades. It has a prominent stalk, olive-brown color, operculate asci with amyloid tips, smooth nonguttulate ellipsoid spores, and ITS and LSU nrDNA sequences that place it in *Peziza* s.s. (PLATE 1).

Taxonomy

Peziza oliviae J.L. Frank, sp. nov.

PL. 2

MYCOBANK MB803430

Differs from the genetically related *Peziza lohjaensis* by its smooth spores and North American distribution and from other *Peziza* spp. by its submerged habitat.

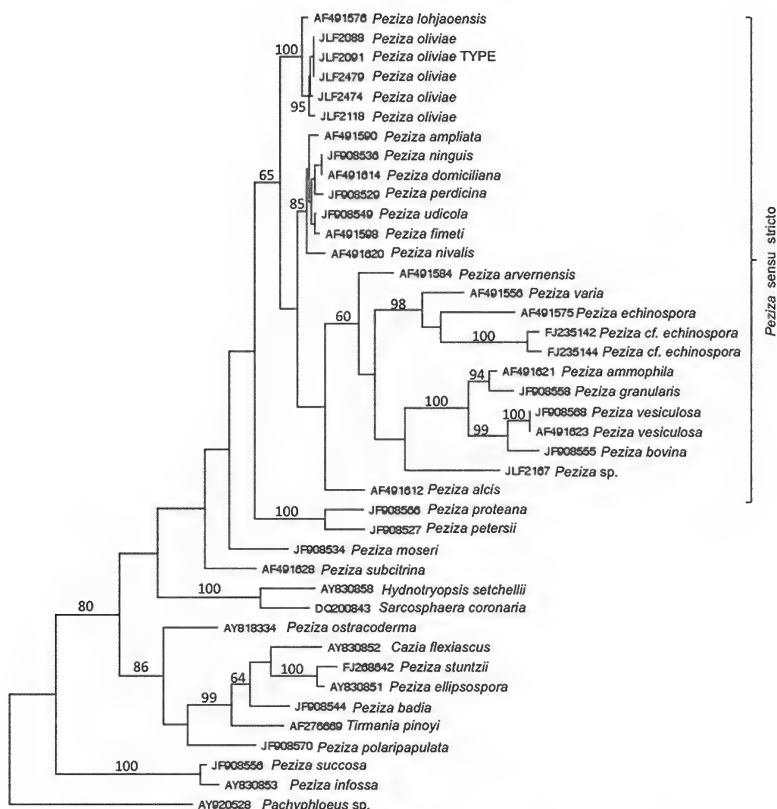


PLATE 1. Maximum Likelihood tree using ITS nrDNA showing the placement of *Peziza oliviae* in *Peziza* s.s. 23,336 rearrangements tried, score of best tree = 9722.72452. MP Bootstrap numbers greater than 50% are included above branches; analyses performed in PAUP* using 1000 bootstrap replicates.

TYPE: United States, Oregon, Marion Co., Willamette NF, Dunlap Creek, UTM E571615 N4962062, elevation 990 m, underwater in stream, 15 Jul 2011, JLF2091 (HOLOTYPE-OSC148300; GenBank JX415340).

ETYMOLOGY: for Doris Olivia for help finding this cryptic cup fungus; also reflecting the olive hue of the ascomata.

ASCOMATA olive to golden-brown stalked cups 7–25 mm tall, 8–40 mm diam, margin crenulate. Stipe 1–10 × 3–7 mm, external surface roughened, glabrous. Ascomal morphology varies from stalked cup or goblet-shape with upturned margin to a nearly sessile slightly convex disc with a short but prominent stalk.

SUBHYMENIUM 15–25 µm thick, composed of small isodiametric cells 4–10 µm. MEDULLARY EXCIPULUM 500–1800 µm thick, composed of large inflated

isodiametric cells $45\text{--}110 \times 35\text{--}85\ \mu\text{m}$. ECTAL EXCIPULUM $50\text{--}150\ \mu\text{m}$ thick, composed of elongate and contorted cells $20\text{--}40 \times 15\text{--}35\ \mu\text{m}$ with olive-brown pigmentation.

ASCI $250\text{--}380 \times 16\text{--}22\ \mu\text{m}$, cylindrical, operculate, arranged in a regular palisade with amyloid tips forming a distinct blue ring zone. PARAPHYSES $3\text{--}5\ \mu\text{m}$ diam, with enlarged clavate tips $5\text{--}8\ \mu\text{m}$ diam equal to or extending slightly ($3\text{--}8\ \mu\text{m}$) beyond the asci, septate with septa $15\text{--}40\ \mu\text{m}$ apart. SPORES nonguttulate smooth ellipsoid $19.5\text{--}24 \times 9.5\text{--}12\ \mu\text{m}$, 8 per ascus.

ECOLOGY & DISTRIBUTION – small streams in the Cascade Range of north central Oregon between 800 and 1500 m elevation, associated with dead woody debris embedded in stream bottoms or on saturated wood, at the stream surface or on stream banks; June through October.

ADDITIONAL SPECIMENS EXAMINED —UNITED STATES. OREGON: MARION CO., Willamette NF: underwater in Dunlap Creek, UTM E584752 N4964113, elev. 990 m, 15 Jul 2011, JLF2087 (OSC148297); UTM E571892 N4962471, elev. 1070 m, JLF2088 (OSC148298; GenBank JX415339); UTM E571641 N4962234, elev. 1010 m, JLF2089 (OSC148299); UTM E577193 N4964125, elev. 1050 m, 27 Jul 2011, JLF2118 (OSC148301; GenBank JX415341); UTM E584753 N4964113, elev. 1212 m, 10 Aug 2011, JLF2140 (OSC148302); UTM E559896 N4957372, elev. 1270 m, 15 Oct 2011, JLF2189 (OSC148303); UTM E571880 N4962471, elev. 1090 m, 27 Jun 2012, JLF2474 (OSC148304; GenBank KC916728); UTM E571935 N4962478, elev. 1120 m, 27 Jul 2012, JLF2541 (OSC148307); below Scorpion Mtn. underwater in E. fork of Humbug Creek, UTM E578141 N4963797, elev. 1295 m, 29 Jun 2012, JLF2479 (OSC148305; GenBank KC916729); underwater in upper Byars Creek, UTM E568438 N4959910, elev. 1240 m, 26 Jul 2012, JLF2538 (OSC148306).

OTHER SPECIES EXAMINED: *Peziza* sp.: UNITED STATES. OREGON: JACKSON CO., Rogue River-Siskiyou NF, underwater in the Rogue River, UTM E540414 N4745695, elev. 995 m, 7 Sep 2011, JLF2167 (OSC148308; GenBank JX415342, KC916727)

COMMENTS– *Peziza oliviae* is distinguished from other species in *Peziza* s.s. by the combination of a stipe, smooth nonguttulate spores, olive-brown pigmentation, its growth underwater or on saturated woody substrates, and its western United States distribution. Among similar species, *P. vesiculosa* lacks a prominent stalk and grows on dung, *P. domiciliana* forms smaller biguttulate spores, *P. echinospora* produces spiny spores, and *P. ammophila* grows in sand and has a cracked margin. Its closest relative, *P. lohjaensis*, is separated by a 20bp difference (>3%) in the ITS1+ITS2 region, warty spores, growth on decaying hardwood litter, and a European distribution (Hansen et al. 2002). Another stalked *Peziza* sp. (JLF2167), collected underwater in the upper Rogue River in southern Oregon, appears to be a distinct species in *Peziza* s.s., but more collections are needed to confirm its taxonomic position and status (PLATE 1).

Peziza oliviae differs from other aquatic or semiaquatic members of the *Pezizaceae* with amyloid asci as follows: *Aquaepeziza* forms globose spores,



PLATE 2. *Peziza oliviae*. A: ascocarp in situ underwater (JLF2189). B: ascocarp with irregular crenulate margin (JLF2189). C: ascocarp (JLF2091). D: ascocarp cross-section (JLF2140). E: spores in asci, amyloid in Melzer's toward the operculate tip (JLF2091). F: spores (JLF2474). Bars: A, B = 1 cm; C = 0.5 cm; D = 1 mm; E, F = 10 µm.

and *Pachyella* and *Adelphella* are non-stipitate and have gelatinous tissues. While the aquatic *Cudoniella clavus* is not closely related, it has many forms including a tan stalked cup that can macroscopically resemble *P. oliviae*, so that surveyors might mistake this for *P. oliviae* in the field. However, *C. clavus* is easily distinguished microscopically by its smaller spores and non-amyloid inoperculate asci.

Peziza oliviae appears to be rare and associated with undisturbed forest habitats. The streams in which *P. oliviae* was collected contained aquatic insect larvae and other ascomycetes including *Vibrissia truncorum*, *V. filisporia*, *C. clavus*, *Scutellinia scutellata*, and *Adelphella babingtonii*. These streams are small and do not experience regular disturbances, such as major sediment moving floods and scouring, as do larger stream systems. These fast-moving small streams, found at 800–1500 m in the central Oregon Cascade Mountains, maintain relatively consistent conditions with temperatures and moisture levels not fluctuating nearly as much as the surrounding terrain. Ascocarps were collected at the bottom of streams attached to woody substrates embedded in gravel and cobble. These fungi did not fruit terrestrially and thus were not subsequently inundated by rising waters. Some fruiting bodies were collected from saturated old logs and log fragments from large conifers (probably *Pseudotsuga menziesii* or *Tsuga heterophylla*) near the water. Growth on dead wood suggests that *P. oliviae*, like other species in *Peziza* s.s. (Hansen et al. 2002), is saprotrophic.

The discovery of this unusual species documents new biodiversity in healthy old-growth forests, underscores the importance of monitoring and maintaining such habitats, and adds to the list of species that represent measurable units affected by adaptive management practices. Its common name, “the olive goblet” (based on its chalice- or grail-like appearance), should help forest managers and surveyors find and identify this unique cup fungus.

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One hundred fourteen years of *Pluteus* in Brazil: collections studied by Hennings and RickNELSON MENOLLI JR.^{1,2*} & MARINA CAPELARI²¹*Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, Campus São Paulo, CCT / Biologia, Rua Pedro Vicente 625, São Paulo, SP 01109-010, Brazil*²*Núcleo de Pesquisa em Micologia, Instituto de Botânica, Caixa Postal 68041, São Paulo, SP 04045-902, Brazil** CORRESPONDENCE TO: menollijr@yahoo.com.br

ABSTRACT — The re-examination of *Pluteus* collections from Brazil studied by P.C. Hennings and J. Rick during the early 20th century expands current Brazilian knowledge of the genus. Searches of the bibliographical and herbarium records revealed a total of 32 *Pluteus* names linked to specimens collected in Brazil and studied by Hennings and Rick. Of the ten species represented by Brazilian types, five types could not be located in any of the consulted herbaria and therefore must be treated as nomina dubia. None of previously published collections listed under five other names could be located. All other collections (in BPI, FH, PACA and SP) were studied for morphology. In all cases, European names originally attributed by Hennings and Rick have been found to be misapplied, and re-identifications based especially on species described from the Neotropics are suggested. Sections *Pluteus* and *Celluloderma* are represented by most collections.

KEY WORDS — biodiversity, *Pluteaceae*, taxonomy

Introduction

Pluteus Fr. (*Pluteaceae*, *Agaricales*, *Basidiomycota*) is a genus represented by approximately 300 species worldwide (Kirk et al. 2008). Although *Pluteus* species are easily recognizable by their free lamellae, pinkish spore print, inamyloid basidiospores, inverse hymenophoral trama, and the absence of annulus and volva (Singer 1986), modern molecular studies have helped resolve taxonomic inconsistencies, establish synonymies of species described multiple times, and enlarge the generic circumscription to include annulate species historically classified in the allied genus, *Chamaeota* (W.G. Sm.) Earle (Minnis et al. 2006, Justo et al. 2011ab, Vizzini & Ercole 2011). However, molecular tools are limited in their ability to resolve taxonomic problems in old

and especially poorly preserved collections. An accurate morphological study is an alternative in these situations, although it is not always possible to retrieve useful information from old collections in which the hymenial structures are frequently collapsed and not revivable.

Paul Christoph Hennings was the first author to describe a *Pluteus* species from Brazil, *P. scruposus* (Hennings 1900) based on material collected by R. Pilger in 1899. Hennings (1904a,b) also described *P. termitum* Henn. from material collected by E.H.G. Ule in 1901 and *P. cervinus* var. *griseoviridis* from material collected by A. Puttemans in 1903.

Hennings was a German mycologist who studied the fungi from Brazil in the late 19th and early 20th centuries. He examined materials collected in different regions of Brazil by many collaborators, including E.H.G. Ule, F.A.G.J. Möller, A.F.M. Glaziou, C.A.W. Schwacke, I.D.J. Huber, C.F. Baker, E.A. Goeldi, A. Puttemans, and R. Pilger (Fidalgo 1968). Hennings was born in 1841 in Heide (Germany) and from approximately 1885 onward devoted himself to the study of fungi from around the world, mainly those from German colonies and Brazil. He published more than 250 papers and brought together in Berlin one of the best fungal collections in the world (Perkins 1909). Many collections described by Hennings were deposited in herbarium B of the Botanical Museum Berlin-Dahlem, which was partly destroyed by fire in a bombing raid in 1943 (Merrill 1943, Hiepko 1987). However, several of Hennings' types were saved because duplicates of different fungal groups (especially Fungi Imperfecti and *Uredinales*) were deposited in other herbaria (Hiepko 1987, Hein 1988). Hein (1988) cited all species described by Hennings and data about the preservation states of these collections in B, but unfortunately no *Pluteus* collections survived the fire in B.

Among Henning's collaborators was Ernst Heinrich Georg Ule, an important and active collector of fungi in Brazil. Ule was born in 1854 in Halle an der Saale (Germany), and in 1883 he moved to Brazil, first living in Santa Catarina state before moving to Rio de Janeiro, where he became a traveling naturalist of the National Museum (Martius 1906, Fidalgo 1968). The *P. termitum* specimen described by Hennings (1904a) was collected during Ule's expedition to the Amazonian Forest in Fortaleza, Amazonas state (19.X.1901–18.XI.1901; Hennings 1904a, Martius 1906). Ule accumulated approximately 3361 species of fungi from the Brazilian States of Santa Catarina, Rio de Janeiro, Minas Gerais, Goiás, and Amazonas (Martius 1906). These collections were distributed to many mycologists, including G. Winter, F.O. Pazschke, H. Rehm, H. Sydow, P. Sydow, E. Jahn, P. Dietel, and P.C. Hennings (Fidalgo 1968).

Other collaborators in Henning's *Pluteus* studies were Robert Pilger and Arsène Puttemans. Pilger, who was born in 1876 in the Heligoland Archipelago (Germany), in 1899 conducted expeditions to the state of Mato Grosso, where

he collected the first *Pluteus* recorded from Brazil. Puttemans, born in Brussels (Belgium) in 1873, moved to Brazil in 1892, where he lived in Rio de Janeiro state for two years before moving to São Paulo. Puttemans, who is undoubtedly the most important name in Brazilian phytopathology, was also an important collector of various non-pathogenic fungi. Although many other collections sent to Germany were destroyed in the fire in B, fortunately duplicates of almost all of Puttemans' collections were deposited in other herbaria, and approximately 7000 samples were preserved at UFRJ of the 'Universidade Federal Rural do Rio de Janeiro' (Fidalgo 1968); additional collections of Puttemans are also preserved in other herbaria, including the type of *P. cervinus* var. *griseoviridis* now deposited in SP ("Instituto de Botânica").

As the study of Brazilian fungi began with foreign collectors, Johann Rick played an extremely important role and is considered the father of Brazilian mycology. In 1904, he started a series of mycological papers representing the beginning of the systematic study of fungi from Brazil (Fidalgo 1962, 1968). His collections brought together approximately 12,000–15,000 exsiccatae from the state of Rio Grande do Sul that are now deposited in PACA of the 'Instituto Anchietano de Pesquisas' (Fidalgo 1968). Rick described and recorded 21 *Pluteus* taxa from that state (Rick 1907, 1919, 1930, 1938, 1961), including seven new taxa from Brazil: *P. cristatulus*, "*P. exiguus* var. *venosa*," *P. fibrillosus*, *P. leptonia*, *P. sensitivus*, *P. straminellus*, and *P. velatus*.

Rick was born in Dornbirn (Austria) in 1869. Around 1896 he began to study fungi and came into contact with H. Rehm, G. Bresadola, and C.G. Lloyd. He shared many duplicates with Lloyd that formed what was most likely the largest collection of Brazilian fungi at the time in the 'Lloyd Herbarium' (Fidalgo 1962). These 'Lloyd Herbarium' collections are now part of the U.S. National Fungus Collections (BPI), which also includes recent collections and contributions from many collectors, giving BPI approximately 14,000 collections representing different groups of fungi from Brazil (Farr & Rossman 2013). After Rick arrived in Brazil in 1903, he was appointed a professor of the Jesuit College of São Leopoldo, Rio Grande do Sul State, where he collected most of his specimens (Fidalgo 1962), including what likely represents his first *Pluteus* specimen (dated 1906 and later identified as *P. cervinus*; Rick 1938, 1961). Rick continued studying Brazilian fungi until 1946, the year he died in Brazil.

Considering that foreign mycologists made the first studies of *Pluteus* from Brazil, many names proposed for European specimens were used for Brazilian materials. The current state of knowledge of *Pluteus* in South America is somewhat problematic, mainly due to the abundance of species described for this region (Singer 1959, Horak 1964) and to misapplied identifications in the past. Nevertheless, there has not yet been any publication correcting past

misapplications. With the aim of complementing the study of *Pluteus* from Brazil, we present our re-examination of historical *Pluteus* collections studied by Hennings and Rick and comment on the identifications. Undoubtedly, studies involving a combination of multiple methods and different types of evidence are relevant for insights into the evolution of the genus and to determine whether morphologically similar taxa from different continents are conspecific or distinct. However, where we have only old or poorly preserved collections, historical studies are equally important for correcting past mistakes involving European names misapplied to South American species and for halting dissemination of errors, such as those involving the geographical distribution of certain species.

Materials & methods

The materials examined herein include types and other *Pluteus* collections studied by Hennings and Rick and cited in their publications (Hennings 1900, 1904ab; Rick 1907, 1919, 1930, 1938, 1961). We also re-examined unpublished collections that they studied. To locate as many collections studied by them as possible, we consulted B, BPI, FH, K, KIEL, L, PACA, S, SP, and W; herbarium acronyms follow Thiers (2013). When necessary, additional collections were also studied to help identify specimens.

The taxa are arranged alphabetically according to the names used by Hennings and Rick. Collections studied by them under the name presented in the taxonomic header are listed under SPECIMEN(S) EXAMINED with previously published names followed by an asterisk (*). Under ADDITIONAL SPECIMEN(S) EXAMINED are listed the collections that share the same characters as the materials listed in SPECIMEN EXAMINED but preserved in herbaria under other names. Specimens that do not represent the species suggested for the other materials involved under this name are also listed in ADDITIONAL SPECIMEN(S) EXAMINED, but the correct identification and name are discussed in the text. For each taxon, we comment upon the name attributed by Hennings or Rick and about what these collections actually represent based on our morphological examination. Original descriptions are presented for the taxa described from Brazilian types as well as for published names for which we could not locate specimens. A summary is provided in TABLE 1. Generic and infrageneric concepts follow Singer (1959, 1986) as complemented by Justo et al. (2011a,b).

For microscopic analyses, the dried material was wetted with 70% ethanol and then rehydrated in 5% KOH or stained with Melzer's reagent to determine the amyloid reaction of the spores. The notation [a/b/c] preceding basidiospore measurements = (a) basidiospores were measured from (b) basidiomata taken from (c) collections; Q = range of the length/width ratio for all spores measured; Qm = average of all calculated Q values for all spores measured; and Lm (Wm) = the average of all the lengths (widths) of the measured basidiospores. At least 20 basidiospores from each basidioma were measured in lateral view, and the terms denoting basidiospore shape follow Bas (1969). For the pileipellis having a hymeniderm, the length of the pedicel was included in the measurement of the pileipellis elements, and its length is also reported separately.

Results

Of the 32 names of taxa associated with collections recovered, Hennings studied three and Rick the other 29 (TABLE 1). In addition to the 21 taxa published by Rick (1907, 1919, 1930, 1938, 1961), eight additional names were recovered from his unpublished materials. Of the ten taxa represented by Brazilian types, five were not found in any herbarium consulted, and we now regard these as *nomina dubia*. We were also unable to locate collections bearing five other names listed here. Our suggested identifications are based on species actually described from the Neotropics, making the European names originally applied by Hennings and Rick inappropriate in all cases.

TABLE 1: *Pluteus* species reported from Brazil by Hennings and Rick.

SPECIES	REFERENCES	COMMENTS
" <i>P. brunneopictus</i> "*	Rick 1938, 1961	Probably <i>P. tucumanus</i> and <i>P. cubensis</i>
" <i>P. cervinus</i> "	Rick 1938, 1961	<i>P. xylophilus</i>
<i>P. cervinus</i> var. <i>griseoviridis</i> ^B	Hennings 1904b	Probably <i>P. angustisporus</i>
" <i>P. cervinus</i> var. <i>patricius</i> "	Rick 1907	Not found
<i>P. cristatulus</i> ^B	Rick 1938, 1961	Not found (<i>nomen dubium</i>)
" <i>P. dissimilis</i> "	Unpublished	Probably <i>P. angustisporus</i>
" <i>P. egregius</i> "	Unpublished	<i>P. xylophilus</i>
" <i>P. exiguus</i> "	Rick 1938, 1961	Not found
" <i>P. exiguus</i> var. <i>venosa</i> " ^B	Rick 1961	Probably <i>P. jamaicensis</i>
" <i>P. eximius</i> "	Rick 1919, 1938, 1961	Not found
<i>P. fibrillosus</i> ^B	Rick 1938, 1961	Not found (<i>nomen dubium</i>)
" <i>P. fuscidulus</i> "	Unpublished	Insufficient for study
" <i>P. granulatus</i> "	Rick 1930, 1938, 1961	Probably <i>P. glaucotinctus</i>
" <i>P. hispidulus</i> "	Rick 1919, 1938, 1961	Probably <i>P. yungensis</i>
" <i>P. leoninus</i> "	Rick 1938, 1961	Probably <i>P. conizatus</i>
<i>P. leptonia</i> ^B	Rick 1938, 1961	<i>Entoloma</i> s.l.
" <i>P. longistriatus</i> "	Unpublished	Probably a true <i>P. longistriatus</i>
" <i>P. melanodon</i> "	Rick 1938, 1961	Not found
" <i>P. murinus</i> "	Unpublished	<i>P. allostipitatus</i>
" <i>P. nanus</i> "	Rick 1919, 1938, 1961	Probably <i>P. sapiicola</i>
" <i>P. nanus</i> var. <i>podospileus</i> "	Rick 1938, 1961	Not found
" <i>P. pellitus</i> "*	Rick 1930, 1938, 1961	Probably <i>P. petasatus</i> or another sp. in sect. <i>Hispidoderma</i>
" <i>P. princeps</i> "	Unpublished	Probably <i>P. angustisporus</i>
" <i>P. phlebophorus</i> "*	Rick 1938, 1961	Probably <i>P. sapiicola</i> and <i>P. tucumanus</i>
<i>P. scruposus</i> ^B	Hennings 1900	Not found (<i>nomen dubium</i>)
<i>P. sensitivus</i> ^B	Rick 1930, 1938, 1961	Not found (<i>nomen dubium</i>)
" <i>P. sensitivus</i> var. <i>macrospora</i> "	Unpublished	<i>P. allostipitatus</i>
<i>P. straminellus</i> ^B	Rick 1961	<i>Nomen dubium</i>
<i>P. termitum</i> ^B	Hennings 1904a	Not found (<i>nomen dubium</i>)
" <i>P. umbrosus</i> "	Rick 1919, 1938, 1961	Probably <i>P. angustisporus</i>
<i>P. velatus</i> ^B	Rick 1961	<i>Nomen dubium</i>
" <i>P. wehlianus</i> "	Unpublished	<i>Bolbitiaceae</i> or <i>Strophariaceae</i>

^B = type locality in Brazil; * = species represented by collections of two different species;

Bold font = references that provide collection/herbarium information.

Sections *Pluteus* and *Celluloderma* are represented by the greatest number of collections; the number of sampled collections cited by Justo et al. (2012b) suggest that these two sections are probably the most representative of the genus. A current study (Menolli, Meijer & Capelari, unpublished data) including a morphological revision of *Pluteus* specimens collected during more than 30 years of random field trips throughout South Brazil also reveals a preponderance of species in these sections, further confirming observations on sections *Celluloderma* and *Pluteus* in the Neotropics by Singer (1959) and Horak (1964).

Taxonomy

“Pluteus brunneopictus Berk.” sensu Rick, Iheringia, Sér. Bot. 8: 420. 1961. FIG. 1

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: Santa Maria, 1936, J. Rick s.n. (PACA14522*).

BASIDIOSPORES [20/1/1] $5.0\text{--}6.2(-7.5) \times 3.7\text{--}5.0\text{ }\mu\text{m}$ [$Q = 1.24\text{--}1.35$ (-1.50); $Q_m = 1.31$; $L_m = 5.7\text{ }\mu\text{m}$; $W_m = 4.4\text{ }\mu\text{m}$], broadly ellipsoid to ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS a hymeniderm, composed of sphaeropedunculate or clavate to clavate-pedicellate cells, $27\text{--}40$ (-50) $\times 11.2\text{--}18.7(-22)\text{ }\mu\text{m}$, with a medium to long pedicel ($5.0\text{--}17.5\text{ }\mu\text{m}$ long), thin-walled, with brown internal content, frequently condensed or sometimes dissolved. PLEURO- AND CHEILOCYSTIDIA not recovered. CLAMP CONNECTIONS absent.

ADDITIONAL SPECIMEN EXAMINED — Brazil Rio Grande do Sul: São Leopoldo, 1943, J. Rick s.n. (PACA14531).

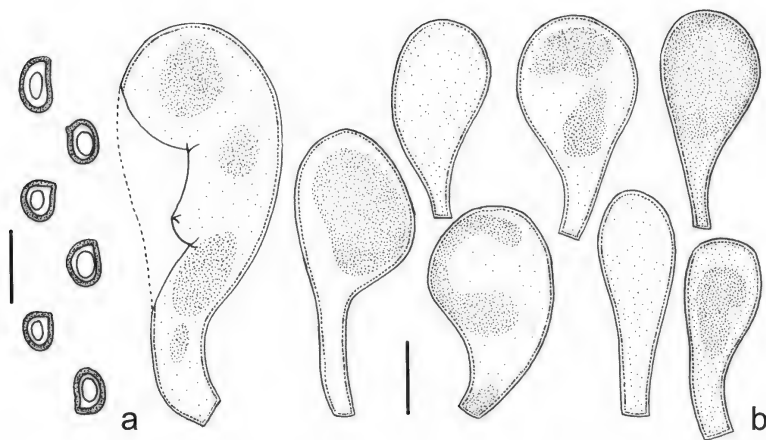


FIGURE 1. *“Pluteus brunneopictus”* (PACA14522).
a. Basidiospores; b. Pileipellis cells. Scale bars = 10 μm .

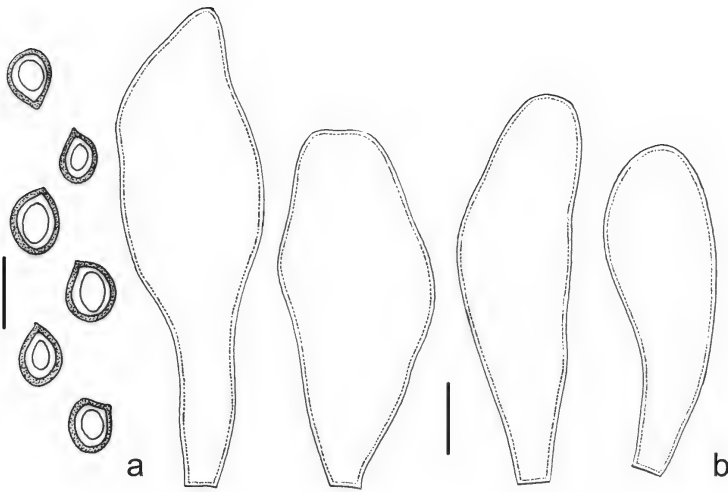


FIGURE 2. "*Pluteus brunneopictus*" (PACA14531).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μm .

COMMENTS — *Pluteus brunneopictus* (Berk. & Broome) Sacc. is an obscure species described from Sri Lanka based on one sample collected in 1868 (Berkeley & Broome 1871, Saccardo 1887). Although there are no recent collections, Singer (1956) and Pegler (1986) re-examined the type and confirmed the occurrence of broadly ellipsoid to ellipsoid basidiospores measuring $5.3\text{--}7.3 \times 4.5\text{--}4.8 \mu\text{m}$ (Singer) and $7.0\text{--}9.0 \times 5.0\text{--}6.0 \mu\text{m}$ (Pegler) and a cellular pileipellis composed of ellipso-pedicellate elements with brownish pigment. Although these data are similar to what we observed in the material studied by Rick (1938, 1961), they are not enough (mainly because pleuro- and cheilocystidia were not found) to correlate it to *P. brunneopictus*.

Moreover, considering the geographical distance, it is unlikely that the specimen collected by Rick in South America actually represents *P. brunneopictus*. Singer (1959) suggested that "*P. brunneopictus*" sensu Rick might be *P. umbrinoalbidus* Singer, *P. rimosoaffinis* Singer, or any other species in stirps *Pulverulentus*, *Jamaicensis*, or *Tucumanus*. Based on the insufficient information available because the hymenial structures were not recovered, we consider that this collection most likely represents *P. tucumanus* Singer, originally described from Argentina. According to Singer (1959), *P. tucumanus* has ellipsoidal basidiospores ($3.8\text{--}5.5 \times 2.7\text{--}3.8 \mu\text{m}$) and subglobose-pedicellate pileipellis cells with dissolved or condensed intracellular pigment, and it represents one of the few South American species

in sect. *Celluloderma* characterized by a predominantly brown pileus color and ellipsoid basidiospores. More collections of *Pluteus* from Brazil and Argentina with these characteristics would be required to establish the actual relationship between Rick's collection and Singer's species and to confirm its occurrence in Brazil.

It is also important to note that Rick (1961) mentioned under *P. brunneopictus* two collections (PACA14522 and PACA14532) made in Santa Maria County in 1936. However, the exsiccata deposited at PACA mistakenly labeled as (PACA)14532 actually contains PACA14531 (Brazil. Rio Grande do Sul: São Salvador, 1943). PACA14531 (FIG. 2) represents an unpublished sample, and our re-examination showed it has broadly ellipsoid to rarely ellipsoid basidiospores measuring $[20/1/1] 6.2-7.5(-8.7) \times 5.0-6.2(-7.5) \mu\text{m}$ [$Q = (1.16-)1.21-1.24 (-1.50)$; $Q_m = 1.24$; $L_m = 7.1 \mu\text{m}$; $W_m = 5.7 \mu\text{m}$], clavate or elongate-ventricose pleurocystidia ($47-68 \times 15.0-22 \mu\text{m}$), a pileipellis that seems to be a cutis with ascendant elements, and no clamp connections. Cheilocystidia were not found. Based on these characteristics and on a current study (Menolli, Meijer & Capelari, unpublished data) that includes a broad examination of collections of *P. cubensis* (Murrill) Dennis, this seems to be the better name for PACA14531. *Pluteus cubensis* is widely distributed in Central and South America, and its representatives display wide morphological variation, especially in basidiospore shape and size.

"*Pluteus cervinus* Schaeff." sensu Rick, Iheringia, Sér. Bot. 8: 418. 1961. FIG. 3

SPECIMENS EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1906, J. Rick s.n. (PACA14519*); 1934, J. Rick s.n. (PACA14516*); 1934, leg. Steffen, det. J. Rick (PACA14526).

BASIDIOSPORES $[62/4/4] (5.0-)6.2-7.5(-8.7) \times (3.7-)5.0-6.2 \mu\text{m}$ [$Q = (1.21-)1.24-1.68$; $Q_m = 1.45$; $L_m = 6.7 \mu\text{m}$; $W_m = 4.8 \mu\text{m}$], broadly ellipsoid, ellipsoid to elongate, inamyloid, hyaline, smooth, thick-walled, guttulate. PLEUROCYSTIDIA of three types: (I) the normal *Cervinus*-type, $58-76 \times 15.0-17.5 \mu\text{m}$, fusoid-ventricose, colorless, hyaline, with four to six apical to lateral prongs at the apices, thick-walled, the wall sometimes tapering toward the base, abundant to very abundant; (II) the modified *Cervinus*-type as the majority of those found in *P. harrisii* Murrill, $56-87 \times 12.5-20 \mu\text{m}$, fusoid-ventricose, colorless, hyaline, usually without prongs and a subcapitate apex or with two short lateral prongs and slightly strangulated at the apex, moderately thick-walled, common; and (III) the *Magnus*-type, $56-78 \times 12.5-21 \mu\text{m}$, lageniform to fusoid, with an acute apex, colorless, hyaline, moderately thick-walled, rare. CHEILOCYSTIDIA not recovered. PILEIPELLIS a cutis. CLAMP CONNECTIONS absent.

ADDITIONAL SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: Pareci Novo, 1918, J. Rick s.n. (SP33928 as "*P. egregius*" Rick).

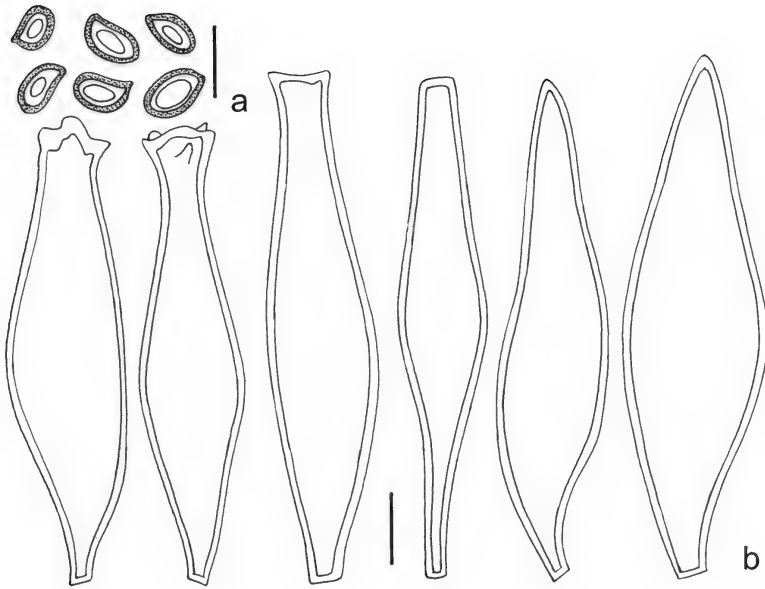


FIGURE 3. "*Pluteus cervinus*" (PACA14519).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μ m.

COMMENTS — Our re-examination of Rick's collections identified as *P. cervinus* shows that they actually represent *P. xylophilus* (Speg.) Singer. Although we were unable to find any cheilocystidia, the characteristic pleurocystidia combined with the basidiospore size and shape and the macroscopic aspect of the pileus are distinctive enough to identify Rick's collections. *Pluteus xylophilus* can be easily recognized by its large pileus, the presence of three types of pleurocystidia, and the broadly ellipsoid to elongate basidiospores (Singer 1959, Menolli et al. 2010). There is much discussion about the identity and circumscriptions of *P. cervinus* (Schaeff.) P. Kumm., and it is likely restricted to the northern hemisphere, as shown in the phylogenetic analyses published by Justo et al. (2011b). As suggested by Singer (1959), almost all collections from Brazil referred to *P. cervinus* are probably *P. xylophilus*, a species well known in South America and which forms a distinct clade in sect. *Pluteus* (Justo et al. 2011b).

Another collection (PACA14529) of *P. cervinus* recorded by Rick (1961) was also not found; however, "PACA14529" may be a typographical error for the specimen PACA14526 that we studied.

Pluteus cervinus* var. *griseoviridis Henn., Hedwigia 43: 204. 1904.

FIGS. 4, 5

SPECIMEN EXAMINED — Brazil. São Paulo: Serra da Cantareira, March 1903, A. Puttemans 871 (Holotype, SP141797).

ORIGINAL DESCRIPTION — “*Pileo carnosus, convexo explanato, centro obtuso, laevi glabro, subglutinosulo, margine striatulo, griseo-viridi, 5–7 cm diam.; stipite solido, cylindraceo, pallido, laevi, glabro, 4–7 × 3–5 μ [sic; = cm], basi incrassato; lamellis liberis, confertis, ventricosus, ca. 3–4 mm latis, flavido-incarnatis; sporis ellipsoideis, 1-guttulatis, carneis, 4–5 × 4 μ; cystidiis lageniformibus, apice 2-vel 3 dentato-hamatis, 40–60 × 15–20 μ.*”

BASIDIOSPORES [100/5/5] 5.0–7.5(–8.7) × (3.1–)3.7–5.0 μm [Q = 1.24–1.70(–2.03); Qm = 1.57; Lm = 6.3 μm; Wm = 4.1 μm], broadly ellipsoid, ellipsoid to elongate, rarely cylindrical, inamyloid, hyaline, smooth, thick-walled, guttulate. PLEUROCYSTIDIA 50–95 × 10.0–24 μm, fusoid-ventricose, colorless, hyaline, mostly of the *Cervinus*-type with four to six apical or lateral prongs, or like those found in *P. harrisii* that are usually without or with two short lateral prongs, sometimes with lateral secondary spinules such as those of *P. spinulosus* Murrill, thick-walled, abundant to very abundant. CHEILOCYSTIDIA not recovered in most collections but a clavate form (39 × 15.0 μm) was found in BPI770905. PILEPELLIS a cutis. CLAMP CONNECTIONS absent.

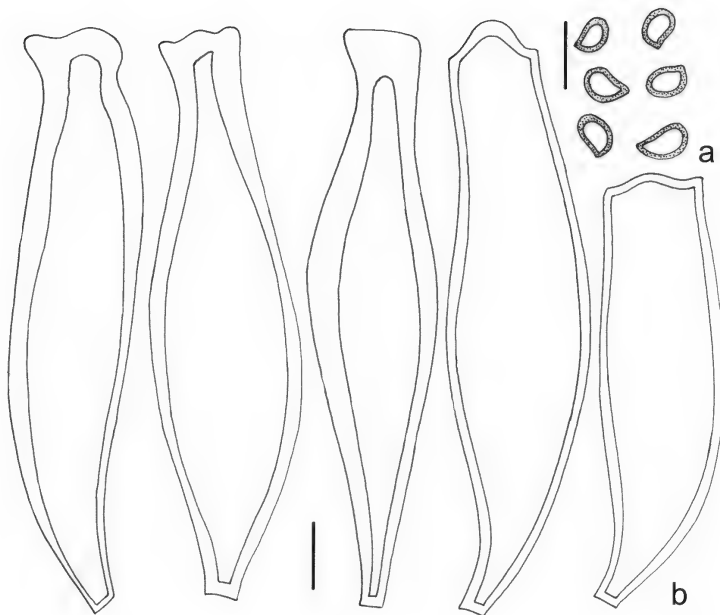


FIGURE 4. *Pluteus cervinus* var. *griseoviridis* (holotype, SP141797).

a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μm.

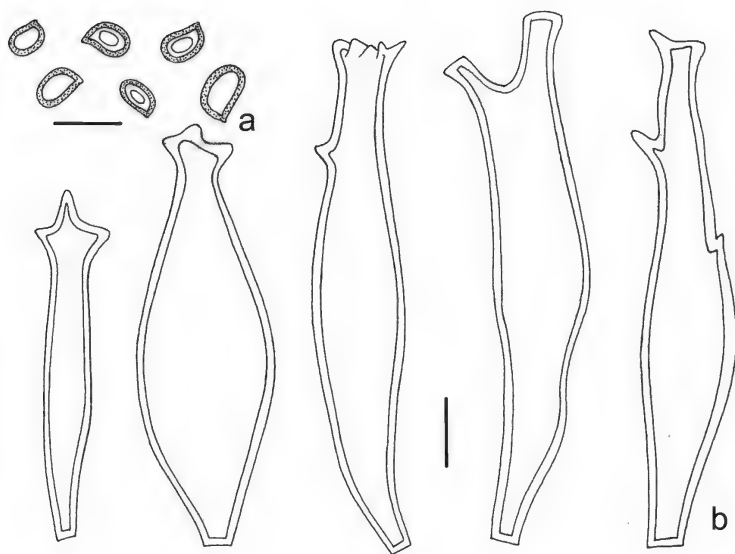


FIGURE 5. "*Pluteus cervinus*" (BPI770858).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μ m.

ADDITIONAL SPECIMENS EXAMINED — Brazil. Rio Grande do Sul: Arroio do Meio, 1920, J. Rick s.n. (SP33926 as *P. cervinus*); 1920, J. Rick s.n. (BPI770858 as *P. cervinus*); 1920, J. Rick s.n. (BPI770893 as "*P. princeps*" Rick); 1920, J. Rick s.n. (BPI770905 as *P. umbrosus*); São Leopoldo, 1929, leg. Steffen, det. J. Rick (PACA14517 as "*P. dissimilis*" Rick).

COMMENTS — Our re-examination of the holotype of *P. cervinus* var. *griseoviridis*, along with some unpublished collections identified by Rick as *P. cervinus* and *P. umbrosus* and others named as "*P. dissimilis*" and "*P. princeps*," showed that they share some morphological features with *P. angustisporus* Singer described from Bolivia (Singer 1959).

Pluteus angustisporus is morphologically close to *P. xylophilus* and *P. harrisii*, from which it differs mainly by the narrow basidiospores and the absence of *Magnus*-type pleurocystidia as found in *P. xylophilus*. Although the collections we examined have large pilei, such as those observed in *P. xylophilus* (≤ 110 mm; Menolli et al. 2010) and much bigger than those reported for *P. angustisporus* (≤ 25 mm; Singer 1959), *Magnus*-type pleurocystidia were not found in any collection studied. In addition, Singer (1959) also reported pleurocystidia with polymorphic apices for *P. angustisporus* like those we observed (FIG. 5). However, due to the condition of the exsiccatæ, it was not possible to confirm the presence of polymorphic cheilocystidia and pileipellis elements as reported by Singer (1959).

Although we cannot confirm the actual identity of these collections, the recovered data indicate that these collections are clearly close to or identical with either *P. angustisporus* or *P. xylophilus*, and we tentatively conclude that *P. angustisporus* is the most appropriate name.

It is important to note that although *P. cervinus* var. *griseoviridis* was described before *P. angustisporus*, if they are the same taxon, the earlier varietal name does not have priority at species rank.

***“Pluteus cervinus* var. *patricius* Schulz.,”** sensu Rick, Brotéria, Sér. Bot. 6: 71. 1907.

ORIGINAL DESCRIPTION — “Pileo 1 dm. lato, crasso, firmo; stipite solido, usque 4 cm. lato, albido, griseo-squamoso. Differt a typo pileo albo, griseo-squamoso, primitus cinereo. Sporis 7–8 μ longis, 5–6 μ latis. Est varietas prorsus identica cum illa a cl. Schulzer in Hungaria lecta. Legi quoque typum.”

COMMENTS — The infraspecific taxon *P. cervinus* var. *patricius* (Schulzer) Massee ($\equiv$ *P. cervinus* subsp. *patricius* (Schulzer) Sacc.) was described from Europe. Although Rick (1907) recorded *P. cervinus* var. *patricius*, he did not cite the collection studied. No sample collected by Rick under this name was found in the herbaria, but it most likely also represents *P. xylophilus*.

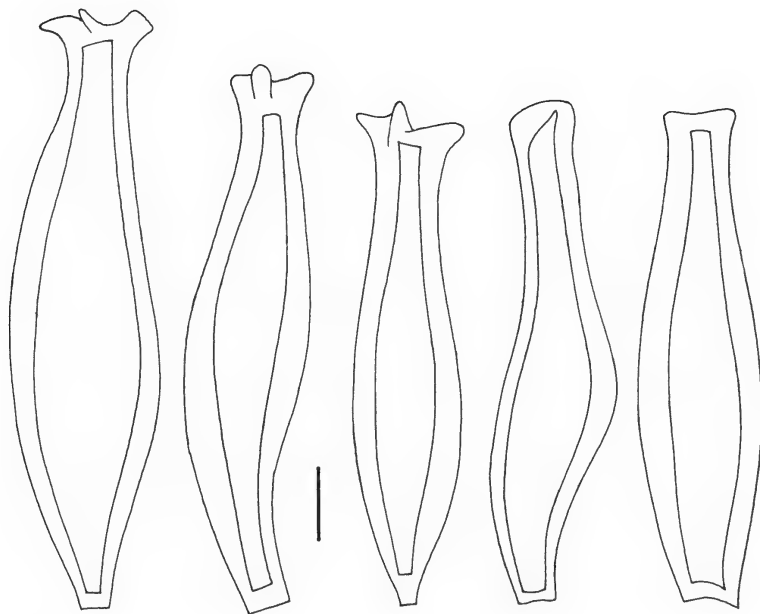


FIGURE 6. Pleurocystidia of “*Pluteus dissimilis*” (PACA14517). Scale bar = 10 μ m.

***Pluteus cristatulus* Rick, Lilloa 3: 445. 1938.**

ORIGINAL DESCRIPTION — “*Pileo membranaceo, albo-brunneo, innato-squamuloso, 1 cm. lato; stipites vitreo, albo-consperso, curto, 2 mm. lato, laterali; lamellis liberis, albis, ventricosus, subconfertis acie serratis, versus stipitem rotundatis; sporis $4.5 \times 3 \mu$ rubris. In trunco. Differt a *Pl. exiguo* lamellis albis serratis, pileo non striato et statura.*”

COMMENTS — Rick (1938, 1961) did not mention the collection studied, and no sample collected by Rick under this name was found in the herbaria. We therefore regard this name as a *nomen dubium*.

“*Pluteus dissimilis* Rick,” nom. in herb.

FIG. 6

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1929, leg. Steffen, det. J. Rick (PACA14517).

COMMENTS — See the description under *P. cervinus* var. *griseoviridis*, with which it shares the same features. It probably represents *P. angustisporus*.

“*Pluteus egregius* Rick,” nom. in herb.

FIG. 7

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: Pareci Novo, 1918, J. Rick s.n. (SP33928).

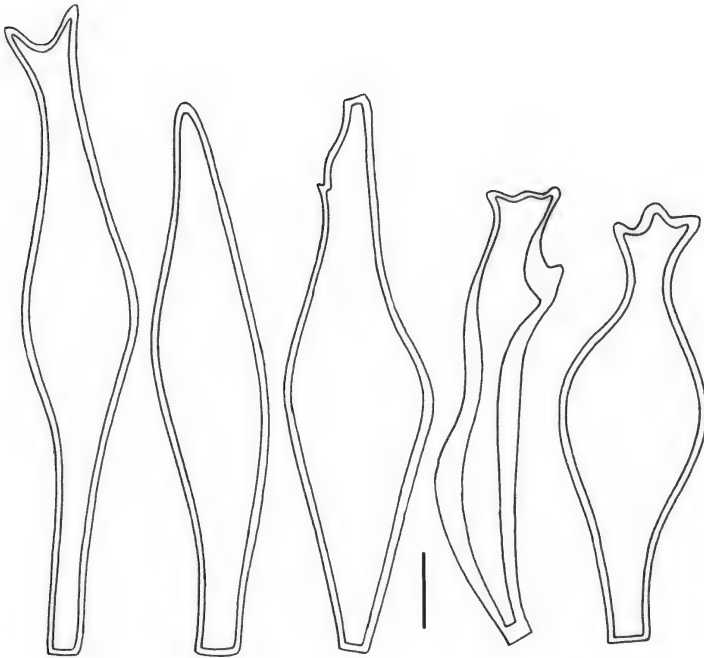


FIGURE 7. Pleurocystidia of “*Pluteus egregius*” (SP33928). Scale bar = 10 μ m.

COMMENTS — See the description under *P. cervinus*, with which it shares the same features. We feel it represents *P. xylophilus*.

“Pluteus exiguus Pat.” sensu Rick, Lilloa 3: 446. 1938.

ORIGINAL DESCRIPTION — “*Pileo convexo, dein plano, tenui, 1–2 cm. lato, initio laevi, dein margine striatulo, pilis brevissimis, erectis, brunneis, flocculosis, velutino, brunneo-rufo, centro obscuriore, lamellis rotundatis inaequalibus, a stipites remotis rufis; stipites fareto, 10–15 mm. longo, basi incrassato, albido, pruinose, non striato; sporis sphaeroides, 1-guttulatis, roseis 6–7 = [x] 3 μ . Ad terram. Pl. nano affinis.*”

COMMENTS — Although Rick (1938) did not mention any collection studied, he (Rick 1961) later referred this name to PACA14518, but the package of this collection is labeled “*P. exiguus* var. *venosa*” (see below). The occurrence of *P. exiguus* (Pat.) Sacc. or any variety of this species in Brazil seems unlikely. It is important to consider that the description of *P. exiguus* presented in Rick (1938, 1961) is almost identical to that provided by Saccardo (1887) and that no other material under this name was located in the herbaria, making it difficult to confirm its occurrence in Brazil. In addition, as far as we know, *P. exiguus* appears to be restricted to Europe, where it has been rarely documented (Kühner & Romagnesi 1956, Orton 1986, Justo & Castro 2007a, Ripková 2009).

***“Pluteus exiguus* var. *venosa*”** Rick, Iheringia, Sér. Bot. 8: 417. 1961, nom. inval. FIG. 8

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: Marcelino Ramos, 1936, J. Rick s.n. (PACA14518, as *P. exiguus* var. *venosa*).

ORIGINAL DESCRIPTION — “*Pileo brunneo, venoso, lamellis mediis, densis, stipite vitreo. Sporis 4–5 my [μ m]. Ad ligna.*”

BASIDIOSPORES [20/1/1] 5.6–7.5 $\times$ (4.6–)5.0–6.2 μ m [Q = (1.09–)1.12–1.24]; Qm = 1.20; Lm = 6.3 μ m; Wm = 5.3 μ m], subglobose to broadly ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS a hymeniderm, composed of subglobose to spheropedunculate cells, 26–37 $\times$ 18.7–26.5 μ m, almost non-pedicellate or with a short pedicel (1.2–3.7 μ m long), thin-walled, with brown dissolved content. PLEURO- AND CHEILOCYSTIDIA not recovered. CLAMP CONNECTIONS absent.

COMMENTS — Although PACA14518 is labeled “*P. exiguus* var. *venosa*,” in the protologue Rick (1961) cited this collection under *P. exiguus*, not under the variety “*venosa*.” As no holotype was designated for the variety, the name is not validly published.

The proposal of a new variety by Rick (1961) seems inappropriate because PACA14518 has a hymenidermal pileipellis more typical of sect. *Celluloderma* than sect. *Hispidoderma* under which *P. exiguus* is classified. The scarce morphological data obtained from Rick’s collection are insufficient to designate a correct name for it, but we agree with Singer (1959) that Rick most likely had

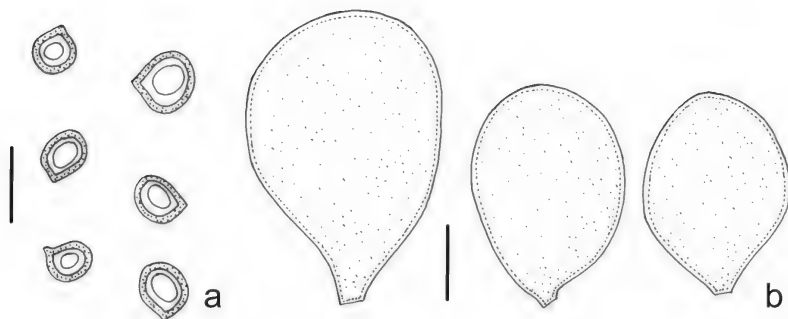


FIGURE 8. "*Pluteus exiguus* var. *venosa*" (PACA14518).
a. Basidiospores; b. Pileipellis cells. Scale bars = 10 μ m.

P. jamaicensis Murrill, which is characterized by non-globose basidiospores [$5.0\text{--}6.8(-7.5) \times 4.5\text{--}6.2\ \mu\text{m}$] and pileipellis cells ($21\text{--}60 \times 20\text{--}45\ \mu\text{m}$) with brown dissolved content (Singer 1956, 1959; Smith & Stuntz 1958; Horak 1964; Pegler 1983; Banerjee & Sundberg 1993; Menolli et al. 2010).

"*Pluteus eximius* Saund. et Sm." sensu Rick, Lilloa 3: 445. 1938.

ORIGINAL DESCRIPTION — "*Pileo laevi, pellicula separabili viscida tecto, rufescenti-umbrino; stipites fibrilloso, demum nigricante. In serragine. Maximus speciosus. Est forma luxurians Pl. cervini.*"

COMMENTS — The English infraspecific taxon *P. cervinus* var. *eximius* (W. Saunders & W.G. Sm.) Massee ($\equiv$ *P. cervinus* subsp. *eximius* (W. Saunders & W.G. Sm.) Sacc.) has never been raised to species rank. Rick (1919, 1938, 1961) did not mention the collection studied, and no sample collected by Rick was found in the herbaria under this name.

Pluteus fibrillosus Rick, Lilloa 3: 444. 1938.

ORIGINAL DESCRIPTION — "*Pileo conico, carnoso, fibrilloso, atro-brunneo, fibris glandulosi ab umbone usque ad margine picto et albo-rimoso usque 5 cm. lato; stipites 1 dm. longo virgineo, laevi, lamellis remotis, confertis, vix ventricosis, versus stipitem liberis et rotundatis; sporis sphaerics 5 μ . Ad terram. Videtur Pl. psichiophoro, albo-lineato et apilopu affinis. Est varietas Pl. longestriati Peck. Hi omnes exceptis 2 primis videntur unam sister speciem proximam Pl. nano Europaeo.*"

COMMENTS — Rick (1938, 1961) did not mention the collection studied, and no sample collected by Rick was found in the herbaria under this name. We therefore regard this name as a nomen dubium.

“Pluteus fuscidulus Fr.” nom. in herb.

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Salvador, 22 Jul 1944, J. Rick s.n. (PACA20926).

COMMENTS — This collection is in too poor condition for study of any microstructures or to gain insights about its identification. Moreover, there is no *Pluteus* (nor *Agaricus*) named by Fries as ‘*fuscidulus*’. Because the collection is unfit for study and the name not attributable to Fries, we have nothing to add to this record.

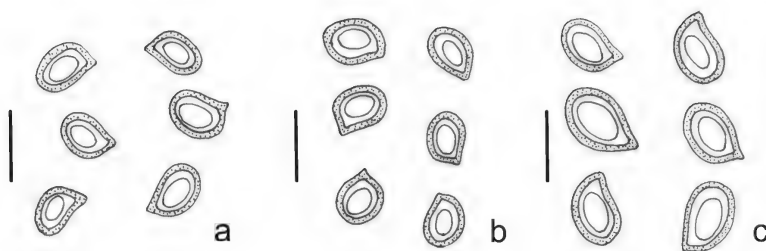


FIGURE 9. Basidiospores. a. *“Pluteus granulatus”* (PACA14523); b–c. *“Pluteus hispidulus”* (b. PACA14528; c. PACA14532). Scale bars = 10 μ m.

“Pluteus granulatus Bres.” sensu Rick, Iheringia, Sér. Bot. 8: 418. 1961. FIG. 9A

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1929, J. Rick s.n. (PACA14523*).

BASIDIOSPORES [20/1/1] $6.2\text{--}7.5 \times 5.0\text{--}6.2 \mu\text{m}$ ($Q = 1.21\text{--}1.50$; $Q_m = 1.28$; $L_m = 7.2 \mu\text{m}$; $W_m = 5.7 \mu\text{m}$), preponderantly broadly ellipsoid or sometimes ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS composed of hyphal elements typical of a cutis but it is too difficult to be recovered. PLEURO- AND CHEILOCYSTIDIA not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — *Pluteus granulatus* Bres. is a rarely recorded mushroom that seems to be restricted to Europe (Saccardo 1887, Kühner & Romagnesi 1956, Orton 1986). It is considered a synonym of *P. plautus* (Weinm.) Gillet, in a broad sense (Vellinga & Schreurs 1985, Legon & Henrici 2011).

Singer & Digilio (1952) recorded *P. plautus* from Argentina, but Singer (1959) later re-identified the collection as *P. argentinensis* Singer. According to Singer (1959), Rick’s collection was misidentified, and our re-examination suggests that it most likely represents some species with a cutis-like pileipellis characterized by an umber fibrillose pileus and broadly ellipsoid to ellipsoid basidiospores. It is possible that Rick had *P. argentinensis*, *P. fastigiatus* Singer,

P. fuliginosus Murrill, or (most likely) *P. glaucotinctus* E. Horak that was recently recorded from Brazil (Justo et al. 2011a,b).

“*Pluteus hispidulus* Fr.” sensu Rick, Iheringia, Sér. Bot. 8: 419. 1961. FIG. 9B, C

SPECIMENS EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, Rick s.n. (PACA14528*); 1932, Rick s.n. (FH00301668); São Salvador, 1943, Rick s.n. (PACA14532*).

BASIDIOSPORES [60/3/3] $6.2\text{--}10.0 \times 5.0\text{--}7.5 \mu\text{m}$ ($Q = 1.16\text{--}1.50$; $Q_m = 1.30$; $L_m = 7.8 \mu\text{m}$; $W_m = 6.0 \mu\text{m}$), broadly ellipsoid to ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS and HYMENIAL STRUCTURES not recovered. CLAMP CONNECTIONS not observed.

ADDITIONAL SPECIMEN EXAMINED — Brazil. J. Rick s.n. (BPI839783).

COMMENTS — Originally described from Europe, *P. hispidulus* (Fr.) Gillet has not yet been definitively recorded from South America. Because our recovered data are insufficient to allow our renaming of Rick's collections, it is not possible to determine what species Rick had collected.

Singer (1959) suggested that this might be a species of sect. *Hispidoderma* (stirps *Fuliginosus*). The most probable species might be *P. yungensis* Singer, which has the biggest basidiospores comparable in size to those observed in Rick's collections. Modern collections with these characteristics are needed to clarify whether *P. yungensis* really occurs in Brazil. We revised another unpublished collection (BPI839783), labeled by Rick as *P. hispidulus*, that actually represents *Entoloma* s.l.

“*Pluteus leoninus* Schaeff.” sensu Rick, Iheringia, Sér. Bot. 8: 417. 1961. FIG. 10

SPECIMEN EXAMINED — Brazil. Rio Grande Sul: São Leopoldo, 1932, J. Rick s.n. (FH00301669).

BASIDIOSPORES [20/1/1] $5.0\text{--}6.2(7.5) \times 3.7\text{--}4.6(5.0) \mu\text{m}$ [$Q = (1.09\text{--}) 1.22\text{--}1.51(1.68)$; $Q_m = 1.37$; $L_m = 5.7 \mu\text{m}$; $W_m = 4.2 \mu\text{m}$], broadly ellipsoid to ellipsoid, rarely subglobose or elongate, inamyloid, hyaline, smooth, thick-walled, guttulate. PLEUROCYSTIDIA $52\text{--}87 \times 12.5\text{--}26 \mu\text{m}$, fusoid-ventricose to lageniform, usually with a rounded apex, metuloid with thickened wall and lacking any apical or lateral horns, frequently with pale straw or colorless internal condensed or dissolved content. CHEILOCYSTIDIA not recovered. PILEIPELLIS difficult to recover but apparently a cutis composed of hyphae with pale brown pigment. CLAMP CONNECTIONS absent.

COMMENTS — *Pluteus leoninus* (Schaeff.) P. Kumm. belongs to sect. *Hispidoderma* and is apparently restricted to the northern hemisphere. The species is characterized by golden yellow basidiomata and thin-walled pleurocystidia with little excrescences at the apex (Singer 1956, Vellinga & Schreurs 1985, Orton 1986, Takehashi & Kasuya 2007). However, “*P. leoninus*”

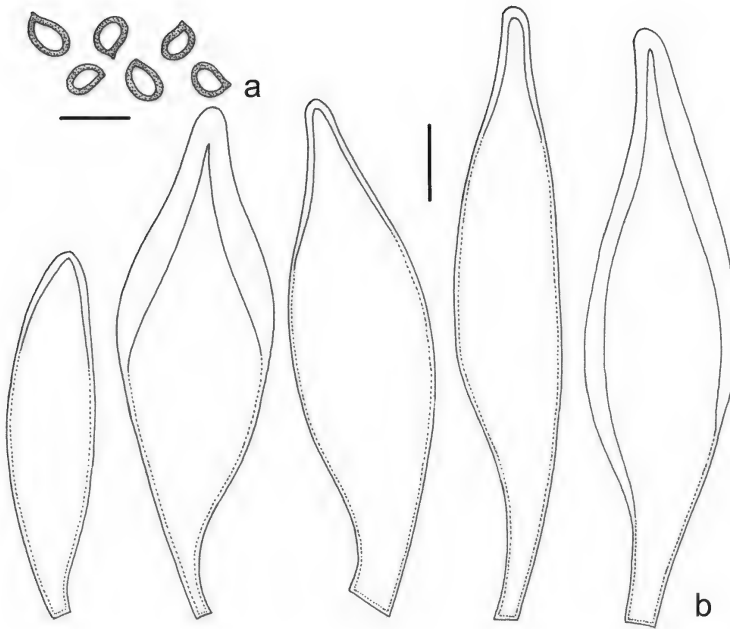


FIGURE 10. "*Pluteus leoninus*" (FH00301669).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μ m.

sensu Rick has thick-walled pleurocystidia. Considering other species with yellowish basidiomata and non-horned metuloidal pleurocystidia, it is likely that Rick had *P. conizatus* (Berk. & Broome) Sacc. or *P. amphicystis* Singer, which differ from each other in pileipellis structure and the absence of metuloid caulocystidia in *P. conizatus* (Singer 1956, 1959; Pegler 1983, 1986; Pradeep et al. 2002). Because the pileipellis in Rick's collection was not well characterized, we verified that the caulocystidia are absent in this collection. We believe that Rick probably had *P. conizatus* instead of *P. leoninus*.

Pluteus leptonia Rick, Lilloa 3: 445. 1938.

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1936, J. Rick s.n. (Holotype, PACA14525*).

ORIGINAL DESCRIPTION — "*Pileo conico, demum expanso-fisso, carnoso, 3–4 cm. lato, subumbonato, laevi, minute ruguloso, exstrio; lamellis aperte liberis, densis, subventricosus, evidenter erosis carnes; stipite usque 1 dm. Longo 5 mm lato, firmo, demum cavo, nudo, striato, cartilagineo; sporis angulatis 7–10 micr. apiculatis. Omnibus partibus pulcherrime*

lazulinus aut coeruleus exceptis lamellis carnis e carne carnea. Odore et sapore nullo. In terra inter Bambusas. Pluteus phaeus Sacc. XVI et sine dubio proximus nisi identicus, sed mea species non crescit in ligno, sed in terra."

COMMENTS — The type of *P. leptonia* is not a *Pluteus*; it is actually a member of *Entolomataceae*. Its basidiospores are predominantly isodiametric, with 5–7 angles. Singer (1956, 1959) mentioned the presence of typical *Rhodophyllus* basidiospores, and he suggested that Rick's collection might represent *Nolanea howellii* Peck or another allied species.

"*Pluteus longistriatus* (Peck)," nom. in herb.

SPECIMEN EXAMINED — Brazil. Rio Grande Sul: São Leopoldo, 1932, J. Rick s.n. (FH00301670).

BASIDIOSPORES [20/1/1] $6.2\text{--}7.5 \times 5.0\text{--}6.8\ \mu\text{m}$ ($Q = 1.07\text{--}1.24$; $Q_m = 1.19$; $L_m = 7.0\ \mu\text{m}$; $W_m = 5.9\ \mu\text{m}$), subglobose to broadly ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS and HYMENIAL STRUCTURES not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — *Pluteus longistriatus* (Peck) Peck, which is common in subtropical and temperate areas of North and South America, is usually recognized by a pileus with a deeply sulcate-striate margin and a hymenidermal pileipellis with heteromorphic elements (Singer 1959, Menolli & Capelari 2010). The macroscopic appearance of FH00301670 suggests that it had a sulcate-striate pileus when fresh, and the basidiospore size and shape agree with those usually reported for *P. longistriatus* (Singer 1959, Menolli & Capelari 2010). Based on these data, we suspect that Rick's collection is actually *P. longistriatus*, but we cannot confirm the identification and the occurrence of this species from the state of Rio Grande do Sul with certainty because the pileipellis and the hymenial structures were not recovered from this collection.

"*Pluteus melanodon* Secr." sensu Rick, *Iheringia, Sér. Bot.* 8: 418. 1961.

ORIGINAL DESCRIPTION — "*Stipite cavo; lamellis acie atris, incisae; an P. umbrosus? Ad lignum.*"

COMMENTS — The European species invalidly described by Secretan was subsequently named as *P. melanodon* (Fr.) Sacc. Rick (1938, 1961) did not mention the collection studied, and no sample collected by Rick under this name was found in the herbaria.

"*Pluteus murinus* Bres.," nom. in herb.

FIG. 11

SPECIMEN EXAMINED — Brazil. J. Rick s.n. (BPI770882).

BASIDIOSPORES [40/2/2] $(6.2\text{--})7.5\text{--}8.7 \times (5.0\text{--})6.2\text{--}7.5\ \mu\text{m}$ [$Q = (1.00\text{--})1.16\text{--}1.24(-1.60)$; $Q_m = 1.19$; $L_m = 7.6\ \mu\text{m}$; $W_m = 6.4\ \mu\text{m}$], preponderantly broadly ellipsoid or sometimes globose or ellipsoid, inamyloid, hyaline, smooth, thick-

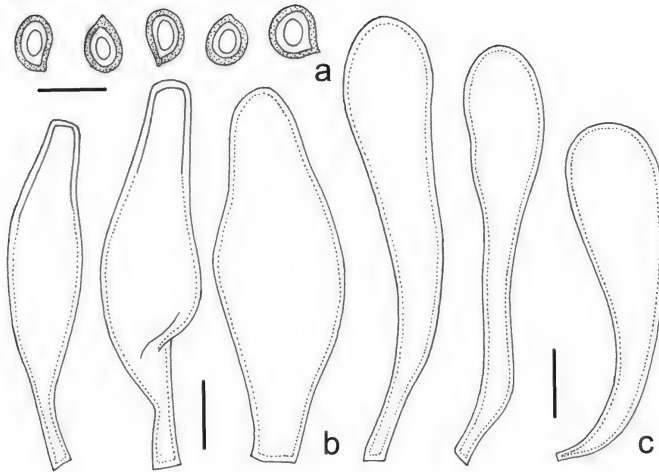


FIGURE 11. "*Pluteus murinus*" (BPI770882).
a. Basidiospores; b. Pleurocystidia; c. Cheilocystidia. Scale bars = 10 μ m.

walled, guttulate. PLEUROCYSTIDIA 51–69(–86) $\times$ 10.0–22.5 μ m, elongate-clavate or slightly ventricose, thin- to relatively thick-walled, sometimes with a colorless internal condensed content. CHEILOCYSTIDIA 50–66 $\times$ 12.5–15 μ m, clavate with a well-developed pedicel at the base, thin-walled, colorless and hyaline. PILEIPELLIS a cutis composed of hyphal elements with a rounded apex and brownish dissolved pigment. CLAMP CONNECTIONS not observed.

ADDITIONAL SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Salvador, 1944, J. Rick s.n. (PACA20770 as *P. sensitivus* var. *macrospora*).

COMMENTS — *Pluteus murinus* Bres., apparently restricted to Europe (Singer 1956, Orton 1986, Banerjee & Sundberg 1993), is considered a synonym of *P. ephebeus* (Fr.) Gillet (Vellinga & Schreus 1985). The data recovered from Rick's collections indicate that it shares the main characteristics found in *P. albobistipitatus* (Dennis) Singer, a widely distributed and commonly cited species with some synonyms and wide morphological variation: mainly the presence of fibrils on the pileus, pleurocystidial wall thickness, and basidiospore size and shape (Menolli et al. 2010; Justo et al. 2011b).

"*Pluteus nanus* Pers." sensu Rick, Iheringia, Sér. Bot. 8: 418. 1961.

FIG. 12

SPECIMENS EXAMINED — Brazil. Rio Grande do Sul: Marcelino Ramos, 1936, Rick s.n. (FH00301671); São Salvador, 29 Feb. 1944, Rick s.n. (PACA22618*).

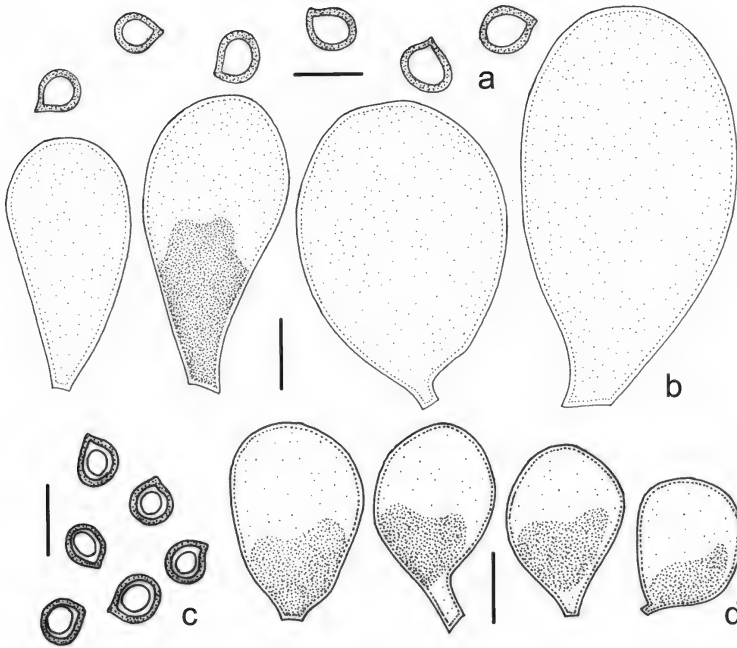


FIGURE 12. "*Pluteus nanus*". (a–b. FH00301671) a. Basidiospores; b. Pileipellis cells. (c–d. PACA22618) c. Basidiospores; d. Pileipellis cells. Scale bars = 10 μ m.

BASIDIOSPORES [40/2/2] $5.0\text{--}7.5 \times 5.0\text{--}6.2\text{--}(7.5)$ μ m [$Q = 1.00\text{--}1.12\text{--}(1.24)$; $Q_m = 1.08$; $L_m = 6.3$ μ m; $W_m = 5.9$ μ m], globose or occasionally broadly ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. **PILEIPELLIS** a hymeniderm composed of subglobose cells, $20\text{--}59 \times 15.0\text{--}34$ μ m, with a short to moderately long pedicel (1.2–10.0 μ m long), thin-walled, with brownish condensed or dissolved content. **PLEURO- AND CHEILOCYSTIDIA** not recovered. **CLAMP CONNECTIONS** not observed.

COMMENTS — *Pluteus nanus* (Pers.) P. Kumm. is a species with many interpretations and seems to be restricted to Europe (Vellinga & Schreurs 1985, Orton 1986, Justo et al. 2007, Justo et al. 2011b). Although there is a suspect record from North America (Homola 1972), it remains unclear if *P. nanus* is really found in the USA according to any of these interpretations (Minnis & Sundberg 2010). Singer (1959) considered Rick's identification to be dubious. Considering the rugose-venose pileus, globose basidiospores, and pileipellis cells with brownish condensed or dissolved content, it is possible that Rick had

P. pulverulentus Murrill or (most likely) *P. sapiicola* Singer, a species known to occur in Brazil (Menolli, Meijer & Capelari, unpublished data). However, other species with pigmented cystidia, such as *P. beniensis* Singer, *P. eliae* Singer, *P. rimosoaffinis*, and *P. riograndensis* Singer, should also be considered.

“Pluteus nanus var. *podospileus* (Sacc. et Cub.)” sensu Rick, Lilloa 3: 444. 1938.

ORIGINAL DESCRIPTION — “*Differt stipite brunneo.*”

COMMENTS — *Pluteus podospileus* Sacc. & Cub. is a widespread European species, distinct from *P. nanus*; it is unlikely that Rick would have collected authentic material in Brazil. Rick (1938, 1961) did not mention the collection studied, and no sample collected by Rick under this name was found in the herbaria.

“Pluteus pellitus Pers.” sensu Rick, Iheringia, Sér. Bot. 8: 418. 1961.

FIG. 13

SPECIMENS EXAMINED — Brazil. Rio Grande do Sul, São Leopoldo, Rick s.n. (PACA14524*); 1931, Rick s.n. (FH00301673); 1932, Rick s.n. (PACA14530*); Sep. 1933, Rick s.n. (FH00301672).

BASIDIOSPORES [80/4/4] (5.6–)6.2–7.5(–8.7) $\times$ (3.7–)5.0–6.2 μm [Q = 1.21–1.51(–1.68); Qm = 1.28; Lm = 6.7 μm ; Wm = 5.3 μm], preponderantly broadly ellipsoid or sometimes ellipsoid, rarely elongate, inamyloid, hyaline, smooth, thick-walled, guttulate. PLEUROCYSTIDIA 61–78 $\times$ 16.2–18.7 μm , slightly ventricose to lageniform, with an amorphous pale straw content, pigmentation usually concentrated at apex and base, thin-walled (recovered only in FH00301673). CHEILOCYSTIDIA and PILEIPELLIS not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — Although there are many concepts of *P. pellitus* (Pers.) P. Kumm., Justo & Castro (2007b) and Justo et al. (2011b) accepted it as a species apparently restricted to Europe and characterized mainly by the white basidiomata, a habitat on angiosperm wood, basidiospores of 5.0–7.5 $\times$ 3.5–5.0 μm , and the presence of clamp connections. Singer (1959) mentioned that “*P. pellitus*” sensu Rick “is obviously *P. viscidulus*,” although he did not cite Rick’s collection in the ‘examined material’ for this species. *Pluteus viscidulus* Singer, another species with white basidiomata but that lacks clamp connections was described from Argentina (Singer 1959) and recorded also from Brazil (from the same State from which Rick’s material was collected). Singer (1959) also recorded *P. viscidulus* from the U.S.A. (Florida), although he mentioned that the North American collection had bigger basidiospores and that this character can be used to separate it from *P. viscidulus*.

Our re-examination of the Brazilian collection determined by Singer as *P. viscidulus* (FIG. 14) [Brazil. Rio Grande do Sul: São Salvador, 9 Nov. 1951, Singer B111 (LIL)] showed that it has broadly ellipsoidal to elongate basidiospores, [20/1/1] (5.6–)6.2(–7.5) $\times$ 3.7–5.0 μm [Q = 1.24–1.68; Qm = 1.35; Lm = 6.3 μm ;

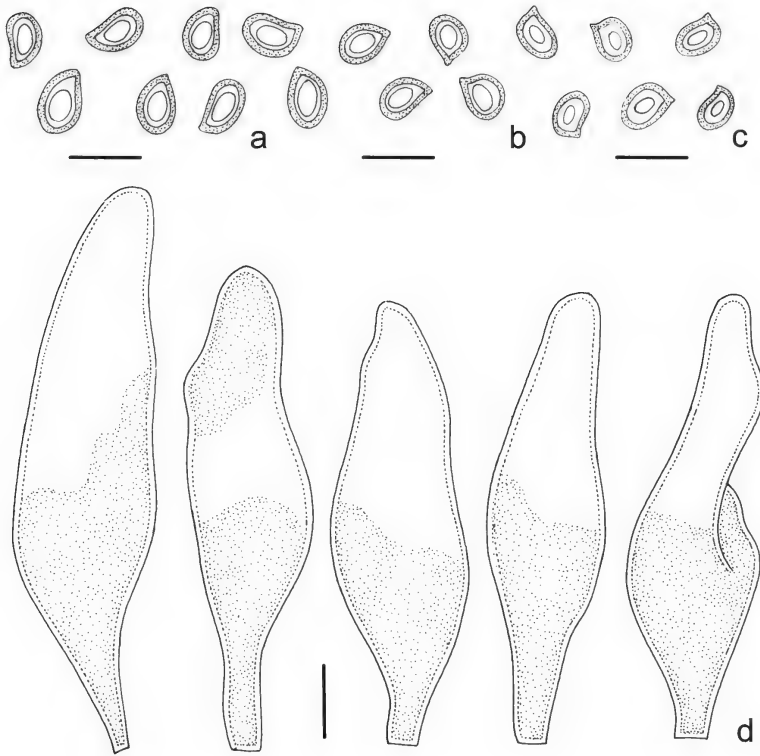


FIGURE 13. "*Pluteus pellitus*". a–c. Basidiospores (a. PACA14524; b. PACA14530; c. FH00301673); d. Pleurocystidia. (FH00301673). Scale bars = 10 μm .

Wm = 4.7 μm], fusoid-ventricose pleurocystidia (69–83 $\times$ 11.2–25 μm) with thick walls and apices with 2–4 lateral prongs, clavate cheilocystidia (37–61 $\times$ 12–15 μm), cutis-like pileipellis, and no clamp connections. Justo & Castro (2007b) found similar features in the isotype of *P. viscidulus*. Until very recently, *P. viscidulus* was thought to represent an authentic South American species with white basidiomata and without clamp-connections; however, molecular analyses by Justo et al. (2011b) place *P. viscidulus* within the molecular variation of *P. petasatus* (Fr.) Gillet, and it is now treated as a synonym of *P. petasatus*. Although *P. petasatus* (= *P. viscidulus*) can be confirmed from Brazil based on Singer's collection, its morphological diagnostic characters were not seen in Rick's collections; the unpublished FH00301673 has thin-walled pigmented pleurocystidia, not the horned pleurocystidia typical of sect. *Pluteus* found

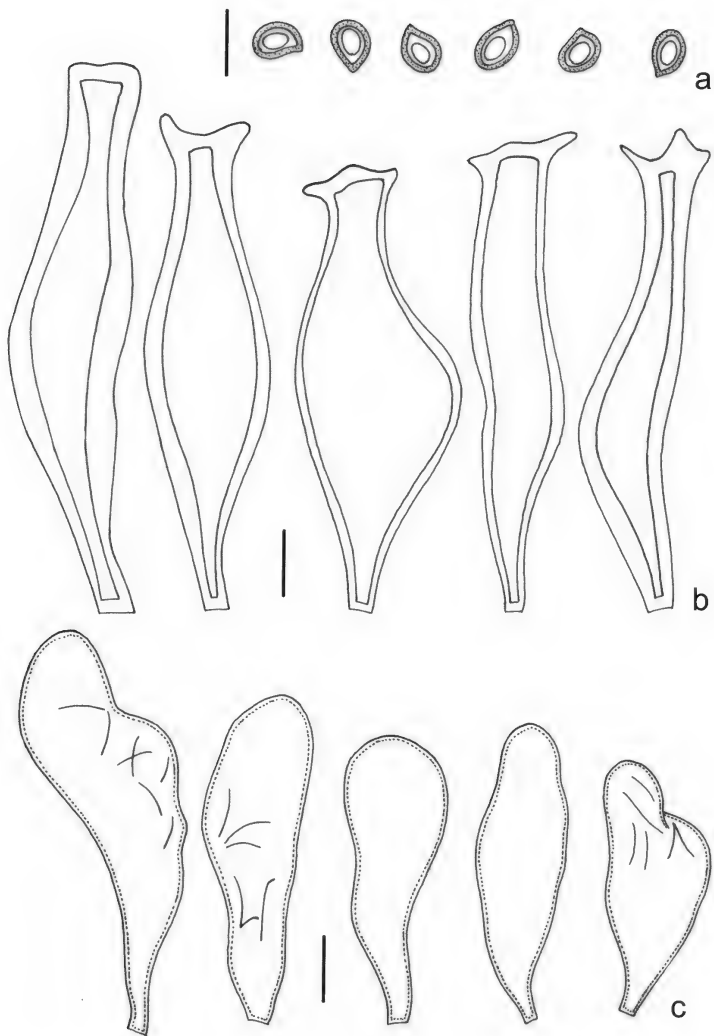


FIGURE 14. *Pluteus viscidulus* (Singer B111, LIL).
a. Basidiospores; b. Pleurocystidia; c. Cheilocystidia. Scale bars = 10 μ m.

in *P. pellitus*, *P. petasatus*, and allied species. In addition, according to notes for FH00301673, Rick denoted it as *P. pellitus* ‘*videtur*’, which indicates that although it resembles *P. pellitus*, a different allied species can also be considered. Because there are no pileus color notes for FH00301673, it is difficult to suggest a name for it. There are no previously published species that combine

broadly ellipsoid basidiospores and pigmented pleurocystidia with a whitish pileus. However, because there is no mention whether the pileus is actually whitish, if we consider only the species of sect. *Hispidoderma* with pigmented pleurocystidia, FH00301673 might represent any species from stirps *Aethalus*, *Circumscissus*, or *Plautus*, according to Singer's classification (Singer 1959).

Although no reliable conclusion can be made about the identity of Rick's collections, we suggest that they do not represent *P. pellitus*. We should not disregard the possibility that the collections (PACA14524, PACA14530) published in Rick (1961) could be *P. petasatus*, and FH00301673 is most likely a species of sect. *Hispidoderma*.

“Pluteus princeps Rick,” nom. in herb.

FIG. 15

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: Arroio do Meio, 1920, J. Rick s.n. (BPI770893).

COMMENTS — See the description under *P. cervinus* var. *griseoviridis*, with which it shares the same features. The above collection probably represents *P. angustisporus*.

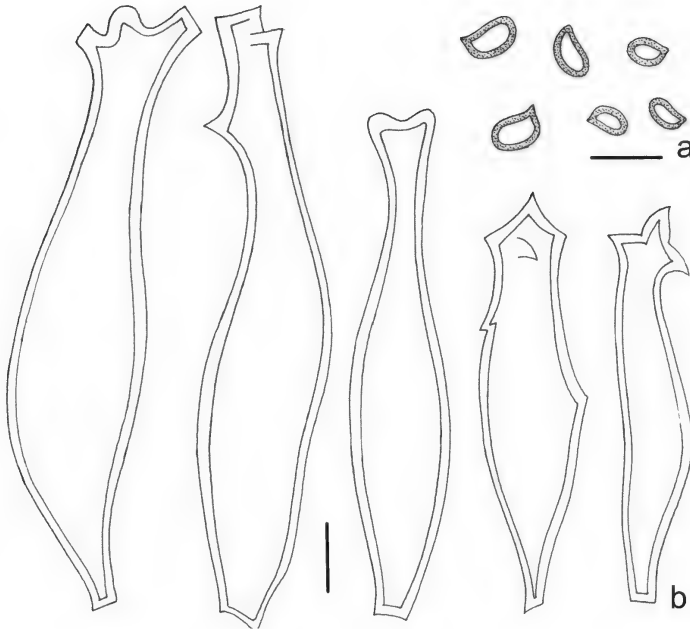


FIGURE 15. *“Pluteus princeps”* (BPI770893).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μ m.

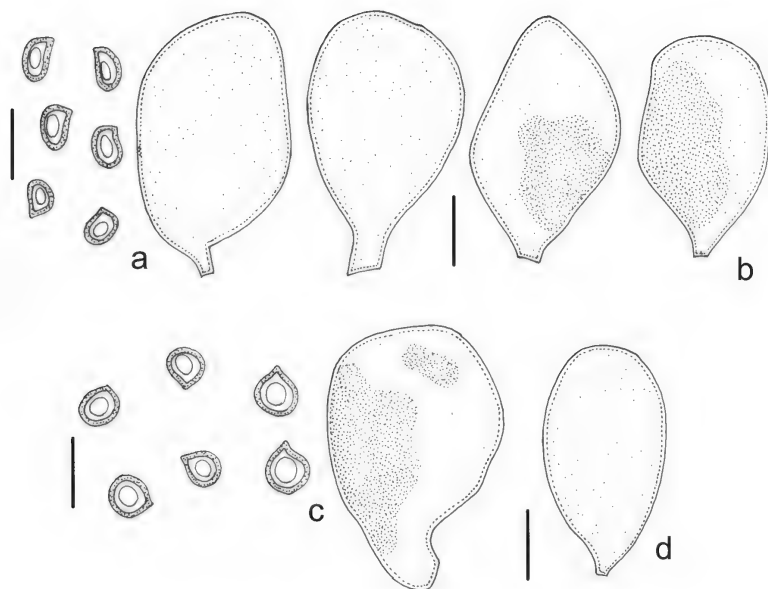


FIGURE 16. "*Pluteus phlebophorus*". (a–b. PACA14520) a. Basidiospores; b. Pileipellis cells. (c–d. PACA20895) c. Basidiospores; d. Pileipellis cells. Scale bars = 10 µm.

"*Pluteus phlebophorus* Dittm." sensu Rick, Iheringia, Sér. Bot. 8: 419. 1961. FIG. 16

SPECIMENS EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1934, leg. Steffen, det. J. Rick (PACA14520*); São Salvador, 28 Jan 1944, J. Rick s.n. (PACA20895).

(PACA14520) — BASIDIOSPORES [20/1/1] $5.0(-6.2) \times 3.7(-5.0)$ µm [$Q = (1.24-1.35)(-1.68)$; $Q_m = 1.39$; $L_m = 5.2$ µm; $W_m = 3.8$ µm], preponderantly ellipsoid or sometimes broadly ellipsoid or elongate, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS a hymeniderm composed of subglobose cells, $24-36 \times 18.7-22$ µm, with a short pedicel (2.5–3.7 µm long), thin-walled, with brownish condensed content. PLEURO- AND CHEILOCYSTIDIA not recovered. CLAMP CONNECTIONS not observed.

(PACA20895) — BASIDIOSPORES [20/1/1] $5.0-6.2 \times 5.0-6.2$ µm ($Q_m = 1.00$; $L_m = 5.7$ µm; $W_m = 5.7$ µm), globose, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS a hymeniderm composed of subglobose cells, $31-36 \times 16.2-25$ µm, with a short to moderately long pedicel (2.5–12.5 µm long), thin-walled, with brownish condensed or dissolved content. PLEURO- AND CHEILOCYSTIDIA not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — These two collections studied by Rick have different anatomical characters and represent two species, although they were both listed as *P. phlebophorus* (Ditmar) P. Kumm. Singer (1959) suggested that “*P. phlebophorus*” sensu Rick is likely *P. jamaicensis*, which is characterized by non-globose basidiospores of $5.0\text{--}6.8(-7.5) \times 4.5\text{--}6.2\ \mu\text{m}$ (Singer 1956, 1959; Smith & Stuntz 1958; Horak 1964; Pegler 1983; Menolli et al. 2010) differing in size and shape from those observed in both of Rick’s collections. PACA14520, which shares characteristics with PACA14522 named by Rick as *P. brunneopictus*, most likely represents *P. tucumanus* (see discussion under *P. brunneopictus*). PACA20895, which most likely represents *P. sapiicola*, is similar to PACA22618, referred by Rick to *P. nanus* (see discussion under *P. nanus*).

Pluteus scruposus Henn., Beibl. Hedwigia 39: 136. 1900.

ORIGINAL DESCRIPTION — “*Pileo carnoso, campanulate, obtuso, scruposo, verrucis crassis atrobrunneis tecto, 2½–3 cm diametro, brunneo; stipites farcto, tereti, albido, laevi, 3½ cm longo, 5 mm crasso, basi bulboso tomentosulo ca. 1 cm incrassato; lamellis liberis, confertis lanceolatis pallidis, dein subincarnatis, cystidiis lanceolatis vel clavate-lageniformibus 55–90 $\times$ 25–35 μ ; basidiis clavatis 35–45 $\times$ 15–20; sporis globosis intus flavido-subincarnatis 15–17 μ .*”

COMMENTS — As we could locate no specimens, we regard this name as a nomen dubium.

Pluteus sensitivus Rick, Brotéria, Sér. Bot. 24: 104. 1930.

ORIGINAL DESCRIPTION — “*Pileo 1 cm lato, campanulato, striato usque ad centrum, membranaceo, viscido, centro brunneo-squamuloso, ceterum fibrilloso, margine hyalino, lamellis confertis, linearibus, acie serratis, rubescentibus, liberis; stipites filiformi 1 mm. lato, 3 cm. alto, vitreo, consperso; spora 4–5 μ , subangulata, grosse guttulata.*”

COMMENTS — Although Rick (1930, 1938) described *P. sensitivus* without indicating a holotype, he later (Rick 1961) cited PACA20770 as the material studied for this species. However, according to the exsiccata notes, PACA20770 represents an unpublished variety, “*P. sensitivus* var. *macrospora*” (see below); moreover, as this specimen was collected in 1944, it cannot be the material on which Rick (1930) based his original description. As no other collection has been found for the epithet *sensitivus*, we regard this name as a nomen dubium.

“*Pluteus sensitivus* var. *macrospora* Rick,” nom. in herb.

FIG. 17

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Salvador, 1944, J. Rick s.n. (PACA20770).

COMMENTS — See the description under *P. murinus*, with which it shares the same features. Although PACA20770 was published under *P. sensitivus* (Rick 1961), the specimen notes cite it as “*P. sensitivus* var. *macrospora*.” Based on

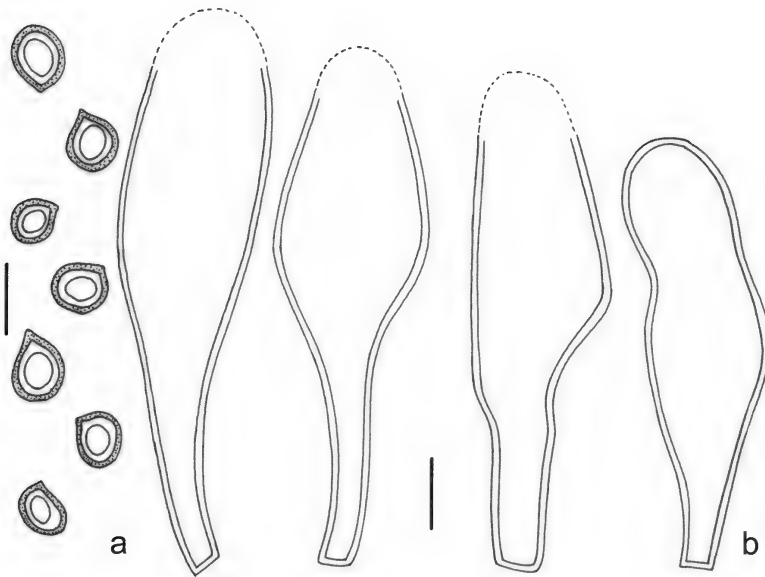


FIGURE 17. "*Pluteus sensitivus* var. *macrospora*". (PACA20770).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μm .

the data recovered from the specimen, we suggest that it may actually represent *P. albospitatus* (see discussion under *P. murinus*).

Pluteus straminellus Rick, Iheringia, Sér. Bot. 8: 417. 1961.

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1930, J. Rick s.n. (Holotype, PACA15531*).

ORIGINAL DESCRIPTION — "*Pileo stramineo, innato-squamuloso, centro lurido, stipite brevi, aquoso; lamellis densis, arcuatis, carneolis, liberis. Sporis 4×3 my [μm]. Ad lignum.*"

BASIDIOSPORES [20/1/1] $3.7(-4.4) \times 2.5(-3.1) \mu\text{m}$ [$Q = (1.42-)1.48$; $Q_m = 1.48$; $L_m = 3.7 \mu\text{m}$; $W_m = 2.5 \mu\text{m}$), ellipsoid, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS and HYMENIAL STRUCTURES not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — Based only on basidiospore size and shape, it is not possible to establish *P. straminellus* as sufficiently well known, leading us to treat it as a nomen dubium. If there were data about the pileipellis and hymenial structures and pileus color, it might be possible to suggest a morphological relationship between *P. straminellus* and other small-spored species, such as *P. microsporus* (Dennis) Singer, *P. ugandensis* Pegler, or *P. unakensis* Murrill.

Pluteus termitum Henn., Hedwigia 43: 183. 1904, as “*termitarum*.”

ORIGINAL DESCRIPTION — “*Pileo carnosulo, campanulato, vertice umbonato-obtuso, brunneolo, radiatim substriato, albido, 3–4 cm diam., stipites fistuloso, tereti, substriato, laevi basi interdum curvulo incrassato, pallido-brunneolo, 4–5 cm longo, 2–3 mm crasso; lamellis liberis, confertis, ventrocsis, ca. 3 mm latis, pallidis dein flavidis; sporis ellipsoideo-fusoideis utrinque acutiusculis, 1–2 guttulis, episporio pallide incarnate, laevi, 7–10 × 4–5 μ.*”

COMMENTS — No specimens can be located. We therefore regard this name as a nomen dubium.

“*Pluteus umbrosus* Pers.” sensu Rick, Iheringia, Sér. Bot. 8: 418. 1961.

FIG. 18

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: Arroio do Meio, 1920, J. Rick s.n. (BPI770905).

COMMENTS — See the description under *P. cervinus* var. *griseoviridis*, with which it shares the same features. The name attributed by Rick (1919, 1938, 1961)

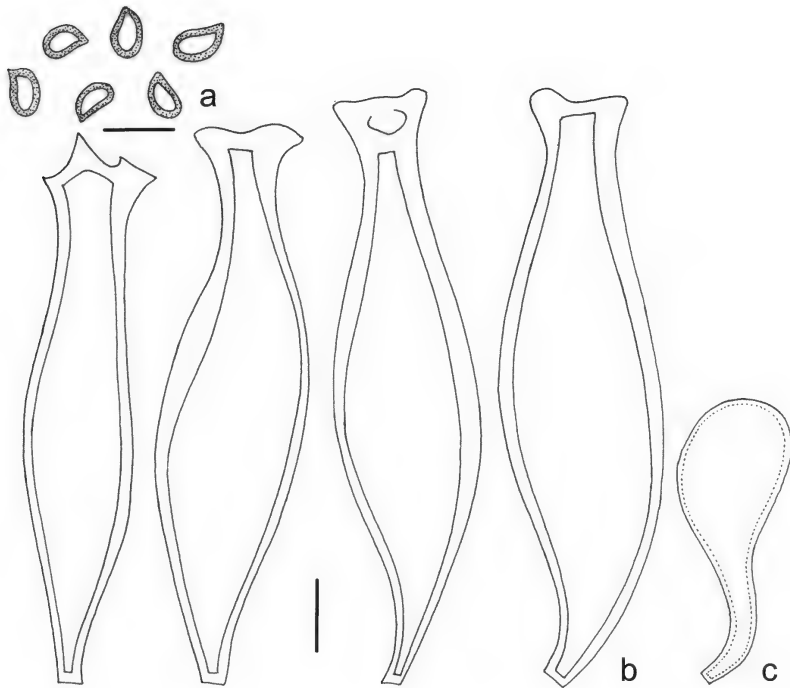


FIGURE 18. “*Pluteus umbrosus*” (BPI770905).

a. Basidiospores; b. Pleurocystidia; c. Cheilocystidia. Scale bars = 10 μm.

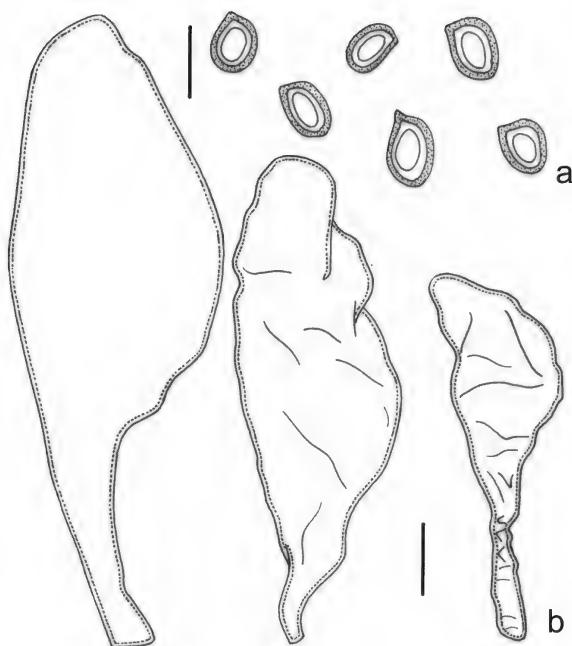


FIGURE 19. *Pluteus velatus* (holotype, PACA14527).
a. Basidiospores; b. Pleurocystidia. Scale bars = 10 μm .

is obviously inaccurate because *P. umbrosus* (Pers.) P. Kumm. represents sect. *Hispidoderma* (Singer 1956, Vellinga & Schreurs 1985, Orton 1986) whereas the above collection has the horned pleurocystidia typical of sect. *Pluteus*. Our morphological examination indicates that Rick's collection probably represents *P. angustisporus* (see discussion under *P. cervinus* var. *griseoviridis*).

Pluteus velatus Rick, Iheringia, Sér. Bot. 8: 417. 1961.

FIG. 19

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1939, J. Rick s.n. (Holotype, PACA14527* as *P. velutinus*).

ORIGINAL DESCRIPTION — “*Campanulatus*, 3 cm latus, griseo-brunneus, membranaceus, squarrosulus ad marginem, secus nudus, fere usque ad centrum leviter striatus; lamellis liberis, ventricosis, densis, albis, margine rubro. Basidiis brevibus, cystidiis paucis, latis; stipite 6 cm alto, 3 cm lato, subtus crassiore, albo-lanoso, ceterum nudo, striatulo, pallido, velo arachnoideo. Sporis 6–10 $\times$ 5–10 μm , polygonalibus, rubris. Ad lignum putridum.”

BASIDIOSPORES [20/1/1] (6.2–)7.5–8.7(–10.0) $\times$ 5.0–6.2(–7.5) μm [Q = (1.16–)1.21–1.50(–1.61); Qm = 1.32; Lm = 7.9 μm ; Wm = 6.0 μm], broadly ellipsoid to

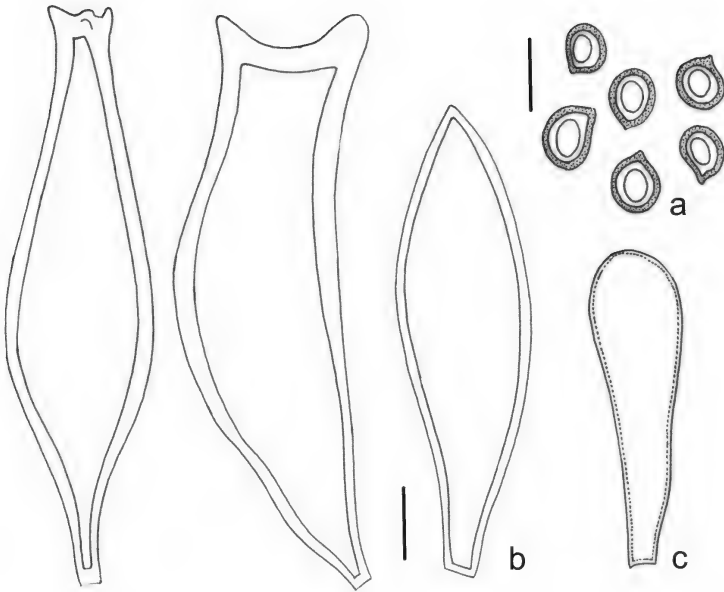


FIGURE 20. *Pluteus fibulatus* (isotype, Singer T141, MICH).
a. Basidiospores; b. Pleurocystidia; c. Cheilocystidia. Scale bars = 10 μ m.

ellipsoid or rarely almost elongate, inamyloid, hyaline, smooth, thick-walled, guttulate. PILEIPELLIS composed of hyphal elements typical of a cutis but it is too difficult to be recovered. PLEUROCYSTIDIA $56\text{--}69(-87) \times (13.7\text{--})18.7\text{--}24(-30)$ μ m, clavate or slightly ventricose, thin-walled. CHEILOCYSTIDIA not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — Singer (1953, 1959) recognized Rick's collection as representing *P. fibulatus* Singer (described from Argentina; Singer & Digilio 1952). Although it is not clear whether Singer actually examined this collection, he did mention that, "the indication of a veil in the unpublished notes must be due to an error." *Pluteus velatus* was published in Rick's posthumous paper (Rick 1961), and according to Singer (1953, 1959), *P. velatus* should be considered a synonym of *P. fibulatus*. However, our re-examination of the two types confirms that they represent different species.

Pluteus fibulatus is typical of sect. *Pluteus*, characterized by a fibrillose deep-colored pileus, clamp-connections, and horned metuloid pleurocystidia

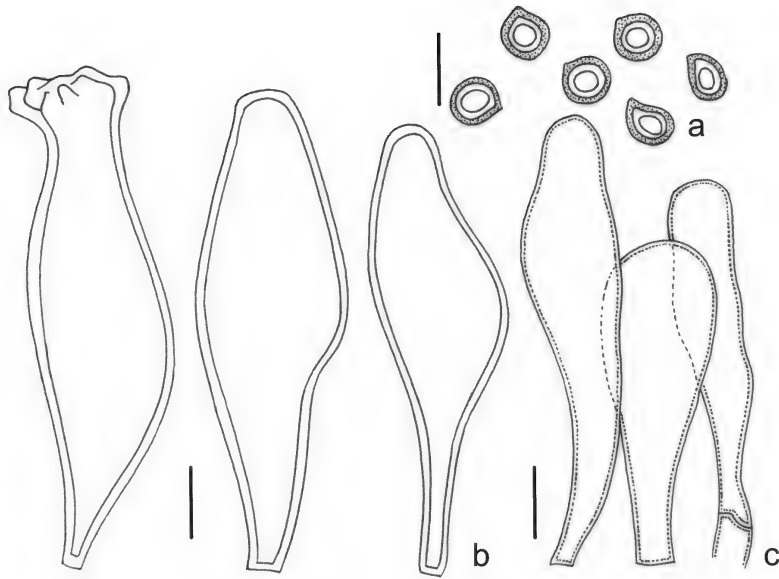


FIGURE 21. *Pluteus fibulatus* (Pegler et al. 3899, K(M)41525).
a. Basidiospores; b. Pleurocystidia; c. Cheilocystidia. Scale bars = 10 µm.

(Singer 1959). Our re-examination of the isotype of *P. fibulatus* [Argentina. Prov. Tucuman: Capital, 22 Feb. 1949, Singer T141 (MICH)] (FIG. 20) showed globose to broadly ellipsoidal (rarely ellipsoidal) basidiospores, [20/1/1] (5.6–) 6.2–7.5(–8.7) × (5.0–) 5.6–6.8(–7.5) µm [$Q = 1.00\text{--}1.24(–1.40)$; $Q_m = 1.16$; $L_m = 7.1$ µm; $W_m = 6.1$ µm]; fusoid-ventricose pleurocystidia (65–88 × 17.5–28.7 µm) with thickened to moderately thickened walls and apices with 2–4 apical prongs (although sometimes without prongs and with an acute to rounded apex), clavate cheilocystidia (44 × 13.7 µm), a cutis-like pileipellis that was difficult to recover, and difficult to detect clamp connections. Similar features were also found in the collection of *P. fibulatus* (FIG. 21) recorded by Pegler (1997) from the state of São Paulo, Brazil [Brazil. São Paulo: Mogi Guaçu, 30 Jan. 1987, Pegler et al. 3899 (K(M)41525)].

However, globose basidiospores and metuloid or horned cystidia were not found in our re-examination of the holotype of *P. velatus*. All pleurocystidia observed in *P. velatus* had thin walls, suggesting that the specimen represents sect. *Hispidoderma* rather than *P. fibulatus* or another species in sect. *Pluteus*. Thus, although we can confirm the occurrence of *P. fibulatus* in Brazil, the

data recovered from Rick's collection are not sufficient to confirm the identity of *P. velatus*, which remains a nomen dubium. Taking into consideration the macroscopic characteristics described by Rick (1961), such as pileus color and lamellae with colored edges ('*marginē rubro*'), as well as the size and shape of the basidiospores and pleurocystidia described herein, it is likely that the material collected by Rick represents *P. fernandezianus* Singer, originally described from Chile (Singer 1959).

"*Pluteus wehlianus* Müller," nom. in herb.

SPECIMEN EXAMINED — Brazil. Rio Grande do Sul: São Leopoldo, 1939, J. Rick s.n. (PACA14529).

BASIDIOSPORES [4/1/1] 16.2–20 × 11.2–12.5 µm (Q = 1.4–1.6; Qm = 1.51; Lm = 18.4 µm; Wm = 12.2 µm), ellipsoid with germ pore. PILEIPELLIS & HYMENIAL STRUCTURES not recovered. CLAMP CONNECTIONS not observed.

COMMENTS — Although referred to *P. wehlianus* (F. Muell.) Sacc., this unpublished collection obviously does not represent a *Pluteus* species due to the large basidiospores with germ pore. It is likely a species of *Bolbitiaceae* or *Strophariaceae*.

Conclusion

Among the names published by Hennings and Rick, only three collections referred to *P. cervinus* could be assigned to the correct name, *P. xylophilus*. Three other unpublished collections could be correctly identified: "*P. egregius*" as *P. xylophilus* and "*P. murinus*" and "*P. sensitivus* var. *macrospora*" as *P. albobistipitatus*. Materials were not found for ten taxa, of which we consider five to be nomina dubia. We also regard *P. straminellus* and *P. velatus* as nomina dubia because the morphological data recovered from Rick's collections are insufficient to confirm their identity.

Of the remainder, we only suggested another name for the collections of Hennings and Rick when it was not possible to recover complete morphological data for a correct identification, although the data available were sufficient to reject the originally applied names. Finally, there is insufficient material of "*P. fuscidulus*" for study, *P. leptonia* belongs to *Entolomataceae*, and "*P. wehlianus*" belongs to *Bolbitiaceae* or *Strophariaceae*.

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A new species of *Bahusutrabeeja* from Guangxi, China

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ABSTRACT — *Bahusutrabeeja exappendiculata* sp. nov. was discovered on rotten branches from subtropical forest of Guangxi Province, China. It differs from previously described *Bahusutrabeeja* species in having colourless globose conidia without appendages. The fungus is described, illustrated and compared with similar taxa.

KEY WORDS — anamorphic fungi, taxonomy

Introduction

During ongoing surveys of saprobic microfungi from subtropical forests of Guangxi Province, China, an interesting anamorphic fungus was collected on rotten branches. Its conidiogenesis and conidia suggest that the fungus belongs in *Bahusutrabeeja* Subram. & Bhat (Subramanian & Bhat 1977).

The type of this genus, *B. dwaya* Subram. & Bhat, has distinct, mononematous conidiophores with integrated, terminal, cylindrical conidiogenous cells. Conidiogenous cells produce conidia in succession by percurrent proliferation from a single fertile locus. The conidia are colourless, smooth, thick walled, aseptate, spherical or rounded-cubical or obpyriform to obclavate, with several to many slender appendages distributed over the surface. They accumulate in a slimy mass at the apex of the conidiogenous cell. The genera *Nawawia* Marvanová (Marvanová 1980) and *Chalarodes* McKenzie (McKenzie 1991), which are similar, were also considered, as they both have macronematous conidiophores, conidiogenous cells each with a single fertile locus producing appendaged conidia in succession by percurrent proliferation. The conidia are,

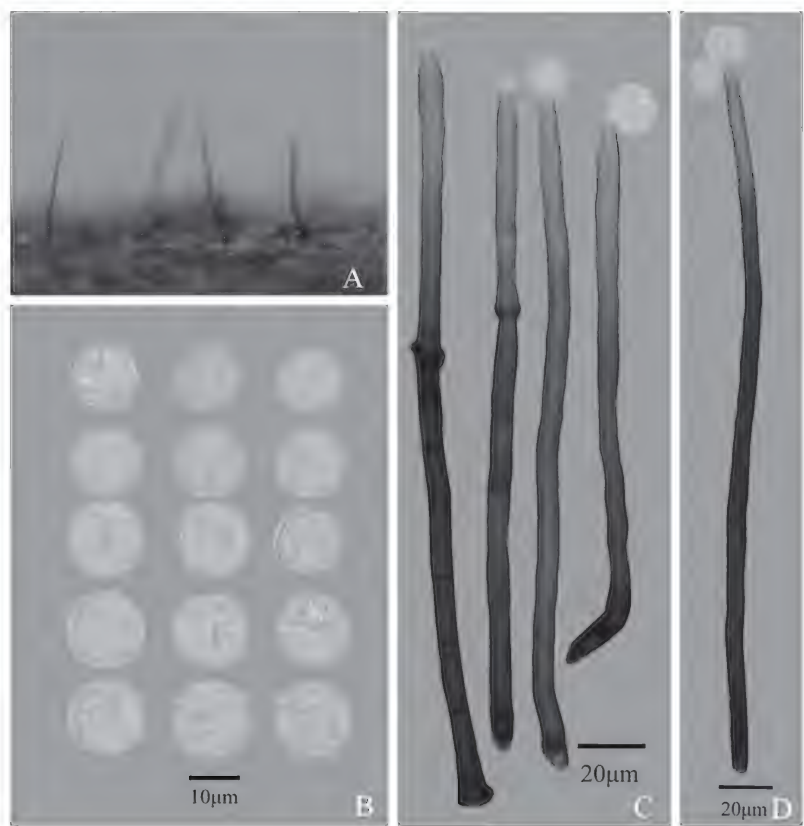


FIG. 1. *Bahusutrabeija exappendiculata*. A. Colonies on natural substratum. B. Globose conidia. C, D. Conidiophores with developing conidia.

however, pyramidal or tetrahedric in *Nawawia*, while in *Chalarodes* they are obconical, with each bearing two distal setulae.

Worldwide, five species are currently included in *Bahusutrabeija*. Those species are separated by conidial shape, size, and appendages (Ma et al. 2011, 2012). All of those species occur on rotten twigs and branches. The present fungus is morphologically distinct from all five previously known species and is, therefore, described here as a new species. A key to all six species is provided.

***Bahusutrabeija exappendiculata* Xiao X. Li & X.G. Zhang, sp. nov.**

FIG. 1

MYCOBANK MB 804166

Differs from all other *Bahusutrabeija* species in having colourless, globose conidia without appendages.

TYPE: China, Guangxi Province: Dayaoshan Nature Reserve, on rotten branches of an unidentified broad-leaved tree, 10 Nov. 2012, Xiao X. Li (**Holotype** HSAUP H 9070; **isotype**, HMAS 243429).

ETYMOLOGY: *exappendiculata*, in reference to conidia without appendages.

COLONIES on the natural substratum effuse, dark brown to blackish, velvety, with scattered conidiophores visible under the stereomicroscope, each with a colourless, globose conidial mass at the tip. Mycelium partly superficial, partly immersed in the substratum, composed of almost colourless to brown, septate, branched hyphae. CONIDIOPHORES mononematous, erect, straight or slightly flexuous, occasionally branched, cylindrical, smooth, thick-walled, 6- to 14-septate, $161\text{--}275 \times 5\text{--}6.5 \mu\text{m}$, dark reddish brown to dark brown at the base which is up to $11.5 \mu\text{m}$ wide, pale brown to brown at the apex, with a single conidiogenous cell at the apex, often proliferating percurrently through the collarette of that conidiogenous cell, and produce further growth with additional septa, and eventually a new conidiogenous cell. CONIDIOGENOUS CELLS terminal, integrated, cylindrical, slightly swollen toward the belly, up to $7.5 \mu\text{m}$ wide, producing conidia by percurrent non-progressive proliferation from a single fertile locus at the apex where there is a prominent, slightly narrower collarette, $3\text{--}4 \mu\text{m}$ wide. CONIDIA colourless, globose, thick-walled, aseptate, $10.5\text{--}16 \mu\text{m}$ diam., without appendages, aggregating in a slimy colourless mass at the apex of the conidiogenous cell.

COMMENTS — *Bahusutrabeeja exappendiculata* differs from all previously described species in the genus in producing conidia with no appendages. The new species resembles *B. dwaya* (Subramanian & Bhat 1977), *B. globosa* Bhat & W.B. Kendr. (Bhat & Kendrick 1993), and *B. bunyensis* McKenzie (McKenzie 1997) in conidial shape and pigmentation. The conidia of *B. exappendiculata* are, however, clearly larger than those of *B. bunyensis* ($7.5\text{--}10.5 \times 7.5\text{--}9.5 \mu\text{m}$), and smaller than those of *B. globosa* ($18\text{--}22 \mu\text{m}$). In *B. dwaya*, the first-formed conidium is pear-shaped while subsequent conidia are spherical.

Key to described *Bahusutrabeeja* species

1. Conidia not spherical 2
Conidia spherical or subspherical 3
2. Conidia angular, $7\text{--}8 \mu\text{m}$ diam. *B. angularis*
Conidia obpyriform to obclavate, $15\text{--}20 \times 5\text{--}8 \mu\text{m}$ *B. dubhashii*
3. Conidia without appendages, $10.5\text{--}16 \mu\text{m}$ diam. *B. exappendiculata*
Conidia with appendages 4
4. Conidia with 3 appendages, $7.5\text{--}10.5 \times 7.5\text{--}9.5 \mu\text{m}$ *B. bunyensis*
Conidia with $8\text{--}12$ appendages 5
5. Conidia $12.5\text{--}14 \mu\text{m}$ diam. *B. dwaya*
Conidia $18\text{--}22 \mu\text{m}$ diam. *B. globosa*

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***Flavophlebia sphaerospora*,
a new corticoid species from India**

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*Department of Botany, Punjabi University, Patiala 147002, India**CORRESPONDENCE TO: avneetbot@gmail.comABSTRACT — *Flavophlebia sphaerospora* sp. nov. is described from Himachal Pradesh, India.KEY WORDS — *Basidiomycota*, Northwestern Himalaya, Narkanda

During the fungal forays conducted during August 2012 in the Hattu Peak area, Narkanda, district Shimla of Himachal Pradesh, India, Maninder and Avneet collected a fungus on decaying wood of *Cedrus deodara* in a mixed forest. After comparison of macroscopic and microscopic characters (Parmasto 1968, Hjortstam & Larsson 1977, Bernicchia & Gorjón 2010, Mycobank 2013) we concluded that the material represented the monotypic genus *Flavophlebia* but differed from *F. sulfureoisabellina* (Litsch.) K.H. Larss. & Hjortstam.

***Flavophlebia sphaerospora* Man. Kaur, Avneet P. Singh & Dhingra, sp. nov. PLATE 1**

MYCOBANK 804821

Differs from *Flavophlebia sulfureoisabellina* by its denser subiculum and its spherical to subspherical basidiospores.

TYPE: India, Himachal Pradesh: Shimla, Narkanda, on way to Hattu Peak, on the bark of decaying wood of *Cedrus deodara* (Roxb. ex D. Don) G. Don, 19 August 2012, Maninder Kaur & Avneet 5166 (PUN, **holotype**).

ETYMOLOGY: The epithet refers to the shape of the basidiospores.

Basidiocarp resupinate, adnate, effused, ceraceous, $\leq 180\ \mu\text{m}$ thick in section; hymenial surface smooth, grayish green to grayish yellow to grayish orange; margins thinning, paler concolorous, to indeterminate. Hyphal system monomitic; generative hyphae branched, septate, clamped; basal hyphae $\leq 3.3\ \mu\text{m}$ wide, more or less parallel to the substrate, thick-walled, forming a dense subiculum; subhymenial hyphae $\leq 2.7\ \mu\text{m}$ wide, vertical, densely united.

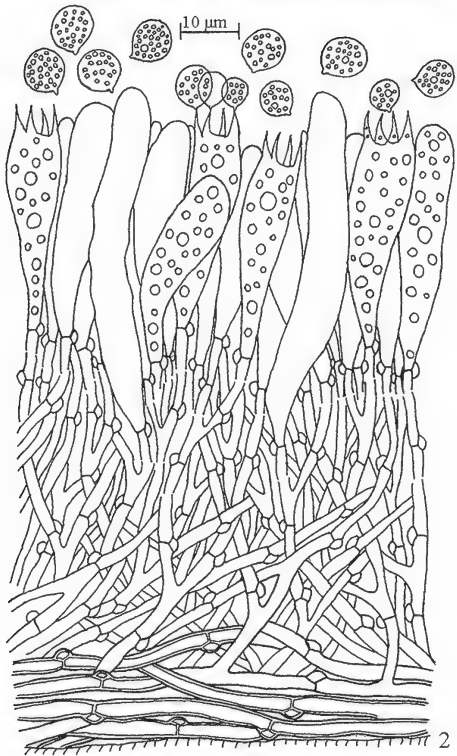
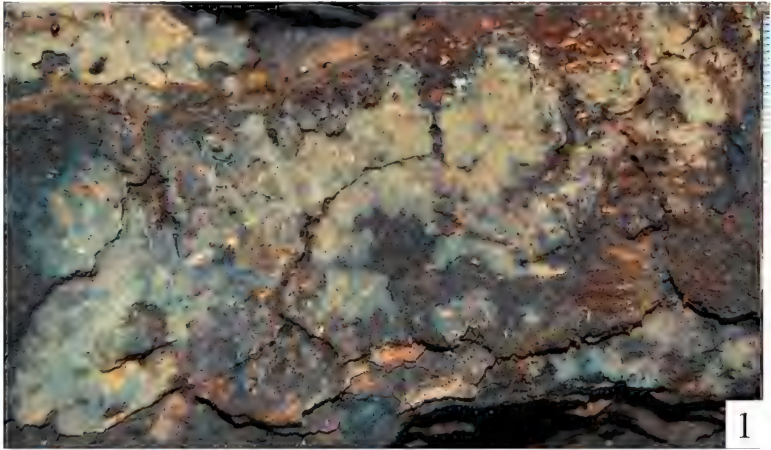


PLATE 1. *Flavophlebia sphaerospora* (holotype). 1. Basidiocarp showing hymenial surface. 2. Vertical section through basidiocarp showing hyphae, basidia, cystidia and basidiospores.

Cystidia 45–60 × 8–8.5 µm, cylindrical, flexuous, thin-walled, with basal clamp. Basidia 28–36 × 8.5–10 µm, clavate, somewhat stalked, 4-sterigmate, with basal clamp, filled with oily contents; sterigmata ≤6.0 µm long. Basidiospores 6.6–8.0 µm in diameter, spherical to subspherical with subapical apiculus reminding of *Radulomyces confluens* (Fr.) M.P. Christ., with numerous oil-droplets, thin- to somewhat thick-walled, inamyloid, somewhat cyanophilous.

REMARKS— Both *Flavophlebia sphaerospora* and *F. sulfureoisabellina* occur on the bark of coniferous trees and have a similar greenish-yellowish colour, but *F. sulfureoisabellina* differs in having a comparatively loose subiculum, ellipsoid to subglobose basidiospores, and slightly narrower basidia.

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***Peniophora hallenbergii* sp. nov. from India**

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ABSTRACT – A new corticioid species, *Peniophora hallenbergii*, is described on a stick of *Rosa indica* from Uttarakhand state in India.

KEY WORDS – *Basidiomycota*, *Agaricomycetes*, Chaurangi Khal, Uttarkashi

While conducting fungal forays in Chaurangi Khal area of district Uttarkashi, Uttarakhand (India), Samita collected an unknown corticioid fungus on a stick of *Rosa indica*. The presence of gloecystidia, metuloids, and smooth inamyloid basidiospores indicates that the material belongs to genus *Peniophora* (Rattan 1977, Eriksson et al. 1978, Boidin et al. 1991, Dhingra 1993, Boidin 1994, Wu 2002, Bernicchia & Gorjón 2010). The material, which keys out near *P. boidinii* but from which it differs in basidiospore shape, is described here as a new species. A portion of the basidiocarp was sent to Prof. Nils Hallenberg (Sweden), who confirmed the findings.

***Peniophora hallenbergii* Samita & Dhingra sp. nov.**

FIGS 1–9

MYCOBANK 804960

Differs from *Peniophora boidinii* by its broadly ellipsoid basidiospores.

TYPE: India, Uttarakhand: Uttarkashi, Chaurangi Khal, on a stick of *Rosa indica* L., 29 September 2011, Samita 5167 (PUN, **holotype**).

ETYMOLOGY: In honor of Nils Hallenberg, Professor Emeritus, University of Gothenburg, Sweden.

Basidiocarps resupinate, adnate, effused, ≤ 180 μm thick in section, hymenial surface smooth, grayish orange; margins thinning, fibrillose, paler concolorous to whitish. Hyphal system monomitic; generative hyphae ≤ 4.5 μm wide, branched, septate, clamped; basal hyphae parallel to the substrate, thin- to somewhat thick-walled, subhyaline to pale brown; subhymenial hyphae vertical, subhyaline, compactly arranged. Gloecystidia $25\text{--}46 \times 5\text{--}8.5$ μm , few,

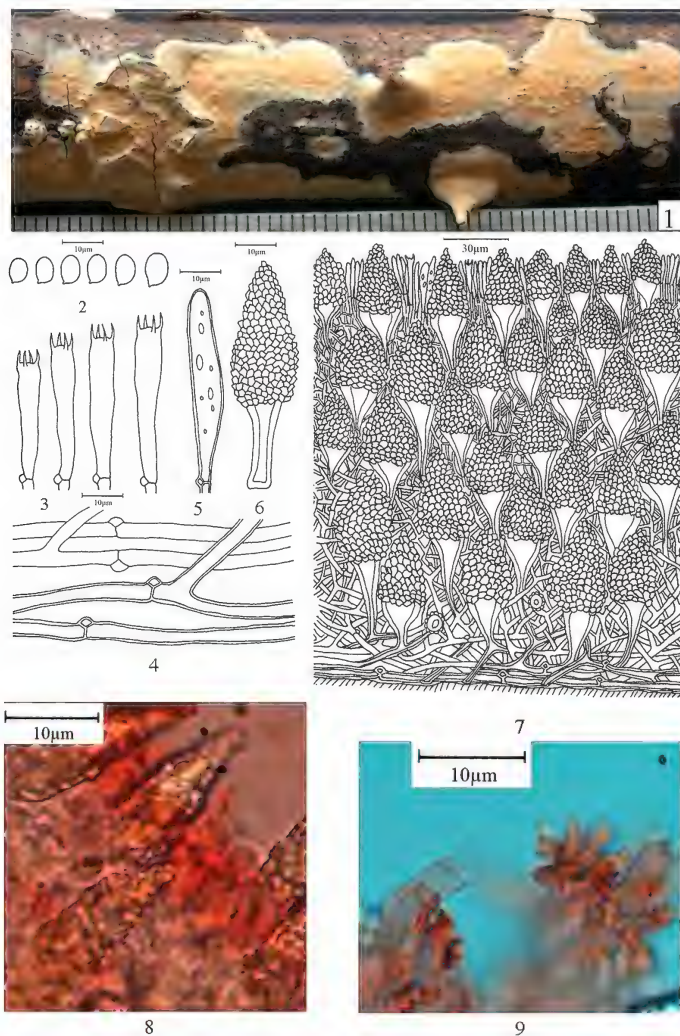


PLATE 1. *Peniophora hallenbergii* (holotype). 1. Basidiocarp showing hymenial surface. 2. Basidiospores. 3. Basidia. 4. Hyphae. 5. Gloeocystidium. 6. Metuloid 7. Vertical section through basidiocarp. 8. Cystidia. 9. Basidia.

subfusiform, slightly thick-walled, negative to sulphovanillin. Metuloids $30\text{--}58 \times 8\text{--}15 \mu\text{m}$, abundant, conical to subfusiform, heavily encrusted, thick-walled, with basal clamp. Basidia $28\text{--}37 \times 3.5\text{--}5 \mu\text{m}$, clavate, 4-sterigmate, with basal clamp; sterigmata $\leq 4.5 \mu\text{m}$ long. Basidiospores $6.3\text{--}8 \times 4.5\text{--}5.6 \mu\text{m}$, broadly ellipsoid, inamyloid, acyanophilous.

ADDITIONAL MATERIAL STUDIED: India, Uttarakhand: Dehradun, Chakrata, on angiospermous wood, 18 September 2012, Samita 5168 (PUN).

REMARKS— *Peniophora hallenbergii* resembles *P. boidinii* D.A. Reid (described from southwestern Europe) in having a similar basidiocarp morphology and two kinds of cystidia. However, *P. boidinii* differs in having narrowly ellipsoid to reniform or subballantoid basidiospores ($6\text{--}9 \times 3\text{--}3.8 \mu\text{m}$).

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BOOK REVIEWS AND NOTICES

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INTRODUCTION

It is a pleasure to compile this present set of reviews of recently published books. Two important European contributions to our knowledge of genera in the *Agaricales* came out, a thorough monograph of *Rosellinia* saw the light, and the book announcements show the results of many more systematic and taxonomic activities concerning various groups of fungi in different places of the world. The book that catches the eye and most attention is THE KINGDOM OF FUNGI by J.H. Petersen, as it is par excellence the way to bring fungi to the attention of everyone.

ASCOMYCOTA

Atlas of soil ascomycetes. By J. Guarro, J. Gene, A.M. Stchigel and M.J. Figueras. 2012. CBS Biodiversity Series 10. CBS-KNAW Fungal Biodiversity Centre, P.O. Box 85176, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. 486, 322 figs. Price 70 €.

Soil fungi are ubiquitous and are found in great numbers in every environmental study focusing on fungi, but their identities often remain obscure.

This atlas gives an overview of the ascomycetes found in soil that make ascomata in culture, and it provides identification tools for this specific group of fungi.

Keys to genera and species, descriptions, and illustrations (photographs and beautifully executed line drawings) will help with the identification process.

* Books for consideration for coverage in this column should be mailed to the Book Review Editor at the address above. All unsigned entries are by the Book Review Editor.

Different culturing techniques and observation methods, and identification criteria are elaborated on.

The genera are presented in alphabetical order, as are the species within each genus.

The authors realize both that the classifications of the treated groups are very much in flux and that these identification methods may soon be replaced by new generation sequencing. Nevertheless, the morphological information presented here is valuable and might give clues to the diverse life styles of these fungi and their environments. It might also stimulate future students and studies in the field. This non-ascomycete-specialist, who spent a pleasurable hour browsing through this volume, certainly hopes that the work will find its place in the hands of many soil biologists and other environment-oriented mycologists.

***Rosellinia* – a world monograph.** By L.E. Petrini, 2013. BIBLIOTHECA MYCOLOGICA 205. Schweizerbart science publishers, Johannesstr. 3A, D-70176 Stuttgart, Germany, < www.schweizerbart.de >. ISBN 978-3-443-59107-6. Pp 410, figs 72. Price 119 €

Rosellinia necatrix and its close relatives are important root pathogens of many woody food plants, but the rest of the genus *Rosellinia* has sparsely been investigated. Liliane Petrini's monograph has changed that dramatically.

The work presented here is an old-school morphological study of herbarium specimens from all over the world. *Rosellinia* fruitbodies are small, inconspicuous, not abundant, and hard to find. The fruitbodies form in stromata on a subiculum; the spores often have appendages or are embedded in a mucous sheath.

A short introduction to the genus and its history, generic and specific delimitation criteria, and a short methodology overview precedes the real part of the book, comprising keys and species descriptions. Species descriptions follow a fixed format, so the descriptions are easily compared; line drawings and photos are included, and keys to species groups and species are dichotomous and arranged by group. A total of 142 species (including 37 new taxa) is treated. The species concept is narrow, and subtle characters in stromatal and spore sizes are used. Some of the new taxa are based on only one collection. Very valuable are the lists of names that are not covered in this work as well as the chapters on geography and ecology of the species. The briefness of the chapter on ecology is an indication of the lack of knowledge on this group. Also included are country and host species lists (each organized by both main categories). The numerous indices make this a very useful book.

So far *Rosellinia* has not undergone phylogenetic studies, but with this monograph and the morphological basis laid, it should be much more feasible.

Sequence data of endophytes could then also be linked to named species. I also hope that more attention will be paid to the ecology and pathogenicity of the species.

Dr. Petrini must be congratulated on the completion of a work certain to become a standard, and I am looking forward to seeing other monographs on equally intriguing and understudied genera in the future.

BASIDIOMYCOTA

Agaricus L. – *Allopsalliota* (Parte II). By L.A. Parra Sánchez . 2013. FUNGI EUROPAEI 1A, 2nd Ed. Candusso Edizioni, Via Ottone Primo 90, I-17021 Alassio (SV), Italy. ISBN 978-88-905310-2-6. Pp 1168, 679 coloured Pl. 89 €

The second part of the volume in the series FUNGI EUROPAEI on the genus *Agaricus* came out in 2013, 5 years after part 1. Luis Alberto Parra Sánchez and colleagues have produced a tome of 1168 pages, in which the European species of sections *Xanthodermatei*, *Arvenses*, *Minores*, and *Lanosi* (in subg. *Lanagaricus*) plus the genus *Allopsalliota* are treated, a total of 56 species.

The format follows that of Part I. Text is in both Spanish and English, and the keys have also been translated into Italian. The descriptions precede 150 pages of illustrations, mainly colour photos of fruitbodies and microscopical characters; multiple entries per species illustrate variability according to age and circumstance. There is a section with published and unpublished older plates, two spore size scatter diagrams, and a number of ITS sequence-based phylogenetic trees showing species relationships and justification for describing some of the new species. Bibliographic references and addenda to the first volume complete this work.

Twelve new species are proposed. Several were only discovered through ITS sequence differences while others are also morphologically supported. Taxonomic confusion from the past is cleared up (as in the case of *Agaricus semotus* and its various interpretations throughout time), and four species are now lectotypified.

It is a pleasure to see Rick Kerrigan, the North American *Agaricus* specialist, honoured with a species named for him, along with József Geml (now in the Netherlands) and Jacques Guinberteau (France). The author also named a species in honour of his wife, and the names of his two children are given to yet another species.

Many more taxa and names than the ones described in full are discussed in the text, and this work is truly a must for every one interested in the group. It also serves as an example of thorough work on a very difficult and daunting

group. The combination of morphological and phylogenetic work is great, and I now await even more eagerly Kerrigan's North American *Agaricus* book that will also combine both sets of characters.

Parra Sánchez is not a professional mycologist in the sense of someone who earns a living by doing mycological research. But the book reflects collaboration with many others in the field (many of the new species are group efforts), and the translations and editing have been done by again another set of people.

It amazes me to see some western North American species present in Europe and vice versa, and I would love to see a biogeographic study of the genus and speculations on migration routes and centres of diversity.

I have one minor bone to pick, which has more to do with the formatting and layout than with the contents. I really miss page headings indicating which species is treated on that particular page; the species entries are long, and one gets easily lost in the sea of words and information.

In short: highly recommended, but because of its weight and bulk definitely not a book for the field.

The genus *Tricholoma*. By M. Christensen & J. Heilmann-Clausen. 2013. FUNGI OF NORTHERN EUROPE VOL. 4. The Danish Mycological Society. Svampetryk, <www.svampe.dk; svampetryk@svampe.dk>. ISBN 978-87-983581-8-3. 228 pp, numerous colour pl. Price 300 DKK. Also available in Danish.

A new book in the series FUNGI OF NORTHERN EUROPE is always a happy event, and this installment does not disappoint.

Tricholoma is the subject, and the authors give a thorough introduction to the genus, including a preliminary tree based on ITS sequences with the promise of a more in-depth article, information on the ecology of the species and where to find species assemblages, and some notes on edibility. The main part presents keys, descriptions, and illustrations of all the treated species. Following are lists of collections on which the descriptions are based, geographical distribution data, interpretation of the colour illustrations in the literature, colour references, and literature references. For a number of species, neo- or epitypes have been selected, which are also elaborated on at the end. Though the title may suggest that only northern Europe is taken into account, the authors have traveled all throughout Europe to gain insight into species diversity, variability, and distribution.

Tricholoma species lack interesting microscopical characters, and identification is for the most part based on the macromorphology: colour and shape of the fruitbodies, the characters of the veil, and the structure of the pileipellis. The keys handle these characters well. The descriptions are good, and the colour illustrations are of high quality; for most species, only one

photo is given, but for some highly variable taxa (e.g., *Tricholoma saponaceum*), the range of variation is illustrated. For each species, spore drawings and a distribution map are given. Short discussions point to comparisons with similar looking species, problems in the literature etc. It is clear that some names have been misapplied in North America.

This is a beautiful and very useful book, not only within Europe, but also outside the continent. I hope that this, together with the North American *Tricholoma* book (Bessette et al. 2013), will stimulate the study of this important ectomycorrhizal genus, which includes one of the most highly valued edible taxa in the world.

Bessette AE, Bessette AR, Roody WC, Trudell SA. 2013. *Tricholoma* of North America. A mushroom field guide. Austin, University of Texas Press. 208 pp.

GENERAL MYCOLOGY

Texas mushrooms. A field guide. By S. Metzler & V. Metzler, 1992; 2013. University of Texas Press, P.O. Box 7819, Austin, TX 78713-7819, U.S.A. <www.utexaspress.com>. ISBN: 978-0-292-75126-2. Pp. 358, numerous colour pl. Price US\$ 23.42 (web)

This is a reprint of the 1992 edition with a new preface, in which the revolutions in mushroom classification of the last 20 years are mentioned. The new classifications resulting from in-depth phylogenetic research show that species first considered closely related because of similarities in morphology (think *Coprinus comatus* and *C. lagopus*, both of which autodigest their lamellae) are now placed in different genera, families, or orders (for the ink cap example above, the genera are now *Coprinus* in the *Agaricaceae* and *Coprinopsis* in the *Psathyrellaceae*). However, as the nomenclature in the book has not been updated according to the newly gained insights, the reader is encouraged to search the Internet and other resources to do so herself.

The quality of the photos, a very important component of a field guide, varies considerably: some pictures are too dark and too blue; others—such as the close-up of *Phyllotopsis nidulans*—are beautiful. Some species are clearly misidentified (e.g., the photo of *Laccaria amethystina* shows *Mycena pura*). And as usual in books like this, the source of descriptions and photos is not revealed.

So far, this is still the only popular book dealing with Texas mushroom species, but I sincerely hope that someone will post updates on the names and a critical evaluation of the species online for all to use, and that future books will reflect our current knowledge and insights.

The Kingdom of Fungi. By J.H. Petersen. 2013. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 U.S.A. <orders@cpfsinc.com>. ISBN 978-0-691-1574-2. Pp 272, 800+ colour pl. Price US \$ 29.95

Also available in other languages (Dutch as 'Het leven van paddenstoelen & schimmels, Danish as 'I svampenes rige', and Estonian as 'Seeneriigi illustreeritud entsüklopeedia'), and as an e-book (eISBN: 978-1-4008-4687-0).

One of the most exciting events for mycology in 2013 was the publication of Jens Petersen's book, *THE KINGDOM OF FUNGI*. It is a book full of beautiful, stunning, and insightful pictures of fungi and mushrooms, interspersed with short pieces of text. But all are so arranged and crafted that in a nutshell a thorough introduction to the kingdom is given and various evolutionary trends are made clear. The book also introduces fungal ecology and the different habitats where these organisms can be found. Mushroom-forming fungi in the *Basidiomycota* and *Ascomycota* (including lichenized species) get the most attention, but other groups feature as well.

It is not a guidebook to identify mushrooms in a certain area; there are photos from many different places, in Europe, Asia, Africa, and South America.

The microphotos of asci and basidia, the close-ups of pores, lamellae, spines, and many other details make you look at the fungal world with different eyes.

The book is above all destined to live on your living room or office table, laid open at one of the detailed photos to convey the message that mushrooms are varied, intriguing, diverse, and still full of mystery for the human viewer.

The low price makes it affordable for many, and if you have not yet bought it, please do so soon, and give it to your students, prospective students, and anybody with the slightest interest in the natural world.

BOOK ANNOUNCEMENTS

Cultivation and diseases of *Proteaceae*: *Leucadendron*, *Leucospermum* and *Protea*.

By P.W. Crous, S. Denman, J.E. Taylor, L. Swart, C.M. Bezuidenhout, L. Hoffman, M.E. Palm & J.Z. Groenwald. 2013 CBS BIODIVERSITY SERIES 13. CBS-KNAW Fungal Biodiversity Centre, P.O. Box 85176, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. 360. ISBN: 978-90-70351-95-3 Print ISSN: 1571-8859. Price 75 €.

Flora of the Guianas Series E: (fungi and lichens) *Cladoniaceae*. By S. Mota de Oliveira.

2013. Kew Publishing <www.kewbooks.com>. ISBN 9781842464793. 150 pp, 60 B&W pl. Price US\$ 99.00.

Operculate Discomycetes (*Pezizales*, *Ascomycota*) of Israel. By G.S. Barseghyan & S.P. Wasser. 2013. BIODIVERSITY OF CYANOPROKARYOTES, ALGAE AND FUNGI OF

ISRAEL. Koeltz Scientific Books, P.O.Box 1360, D-61453 Koenigstein, Germany.
<www.koeltz.com>. ISBN 978-3-87429-442-3. Pp 240, 11 figs. Price 118 €

Ophiostomatoid fungi. By K.A. Seifert, Z.W. de Beer & M.J. Wingfield. 2013 CBS BIODIVERSITY SERIES 12. CBS-KNAW Fungal Biodiversity Centre, P.O. Box 85176, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. 337. ISBN: 978-90-70351-94-6. Price 75 €.

Phytopathogenic *Dothideomycetes*. By P.W. Crous, G.J.M. Verkley & J.Z. Groenewald (eds). 2013. STUDIES IN MYCOLOGY no. 75. CBS-KNAW Fungal Biodiversity Centre, P.O. Box 85176, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. 406, illustr. Price 70 € (paper copy, download free)

Plant pathogenic and endophytic *Botryosphaeriales* known from culture. By A.J.L. Phillips, B. Slippers, J.Z. Groenewald & P.W. Crous (eds). 2013. STUDIES IN MYCOLOGY no. 76. CBS-KNAW Fungal Biodiversity Centre, P.O. Box 85176, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. 167, illustr. Price 65 € (paper copy, download free)

The lichens and allied fungi of Great Smoky Mountains National Park. An annotated checklist with comprehensive keys. By J.C. Lendemer, R.C. Harris & E.A. Tripp. 2013. MEMOIRS OF THE NEW YORK BOTANICAL GARDEN 104. The New York Botanical Garden Press, 2900 Southern Boulevard, Bronx, NY 10458-5126, U.S.A. <nybgpress@nybg.org>. 164 pp. ISBN 978-0-89327-521-1. Price US\$55.00.

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Regional annotated mycobiotas new to the Mycotaxon website

ABSTRACT — MYCOTAXON is pleased to announce three new species distribution lists to our ‘web-list’ page covering *Cortinariaceae* in Argentina (by Romano & Lechner), lichens in Iran (by Valadbeigi), and lichenized and lichenicolous fungi in Spain’s Balearic Islands (by Atienza & al.). The 6th edition of the myxomycetes and larger asco/basidiomycetes in Turkey by Sesli & Denchev has also been uploaded. This brings to 110 the number of free access mycobiotas now available on the MYCOTAXON website:
<http://www.mycotaxon.com/resources/weblists.html>

SOUTH AMERICA

Argentina

G.M. ROMANO & B.E. LECHNER. The *Cortinariaceae* of Argentina’s *Nothofagus* forests. 35 p.

ABSTRACT — We present a checklist of species in the *Cortinariaceae* (*Agaricales*) described from the *Nothofagus* forests of Argentina up to 2013. Names of the 247 species in *Cortinarius*, *Dermocybe*, *Descolea*, and *Stephanopus* have been revised and are accompanied by references and updated distributions.

EUROPE

Spain

VIOLETA ATIENZA, ELENA ARAUJO, MARÍA DEL ROSARIO ARROYO, ANA ROSA BURGAZ, GEMMA FIGUERAS, ANTONIO GÓMEZ-BOLEA, NESTOR L. HLAUN, XAVIER LLIMONA, ESTEVE LLOB, MARÍA EUGENIA LÓPEZ DE SILANES, BERNARDA MARCOS, ISRAEL PÉREZ-VARGAS, RAQUEL PINO-BODAS, ESTELA SERIÑÁ & VÍCTOR J. RICO. Lichenized and lichenicolous fungi from the Pitiüses Archipelago (Eivissa and Formentera Islands and Islets), Balearic Islands, Spain. 36 p.

ABSTRACT — A preliminary checklist for the lichenized and lichenicolous fungi from the Pitiüses Archipelago in the Balearic Islands is presented, based on original records complemented with literature references. The catalogue of our collections in the Pitiüses Archipelago contains 302 lichens and lichenicolous fungi. To date, the checklist, together with records from the literature, include 360 lichens and

lichenicolous fungi, representing 113 genera. *Muellerella lecanactidis* is a new record for Europe, 6 lichens and lichenicolous fungi are new for Spain and the Iberian Peninsula, 57 for the Balearic Islands and 116 for the Pitiüses Archipelago.

MID-EAST

Iran

TAHEREH VALADBEIGI. Lichen flora of the Ilam Province, South West Iran. 7 p.

ABSTRACT — 121 lichen species are recorded as new to the Ilam province, and four species, *Candelariella rosulans*, *Lecanora sulphurata*, *Lecidella scabra*, and *Lecanora klauskalbii*, are new to Iran. Two newly reported species, *Verrucaria macrostoma* and *Xanthoria candelaria*, have not been seen since 1957.

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bad taxonomy



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